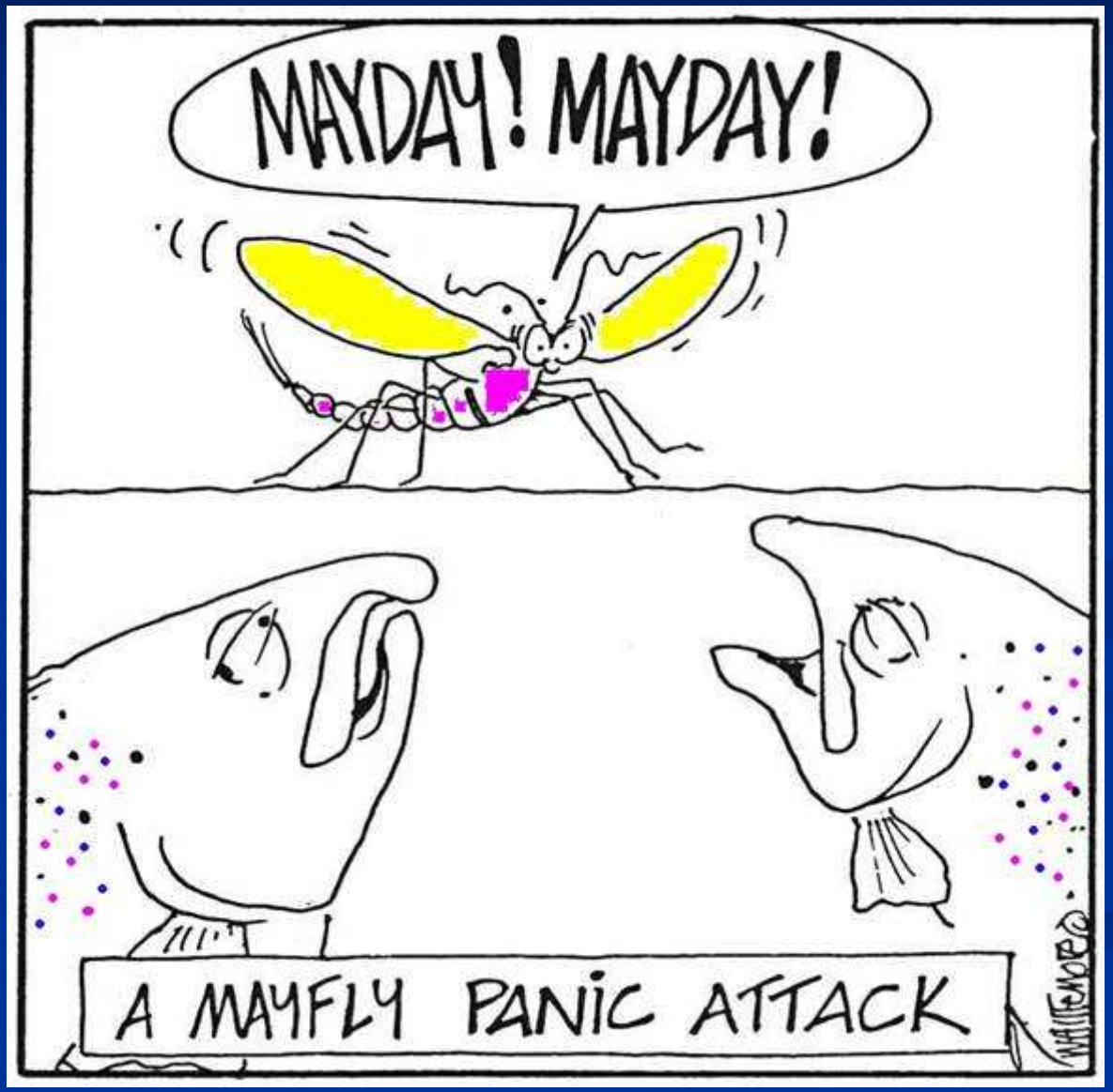

BIOLOGICAL
MONITORING

Benthic Macroinvertebrates

- **Benthic** =
  - Stream bottom
- **Macro** =
  - Can see without microscope
- **Invertebrate** =
  - Organism without a backbone

Vital in Stream Ecosystems



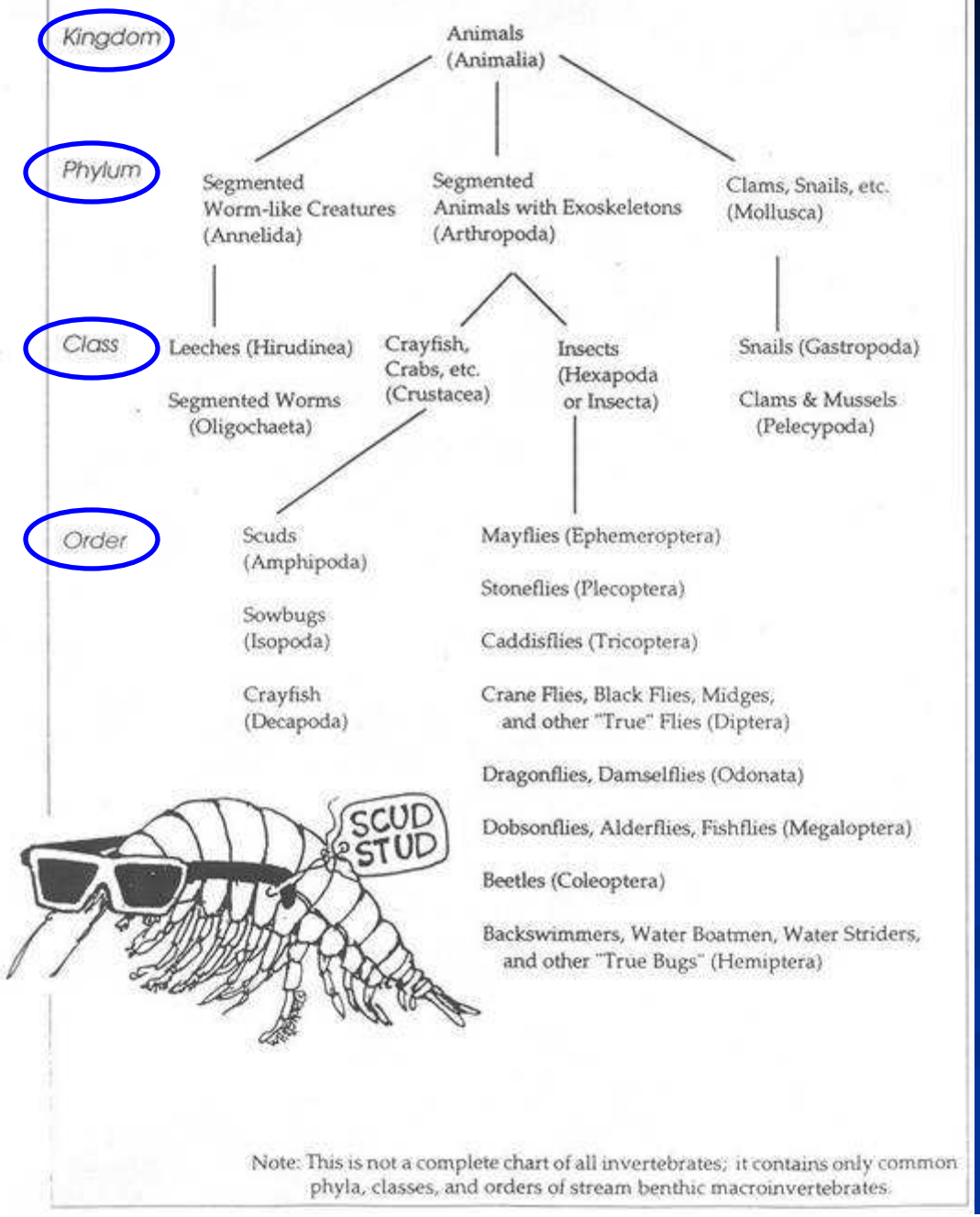
ADVANTAGES

- Non-Mobile
- Species with Different Tolerances
- Continuous Monitoring
- Easy to Collect
- Inexpensive Equipment
- Easy to Identify
- No Chemicals Needed

Nymph

Larva

BENTHIC MACROINVERTEBRATE (BUG) CLASSIFICATION



Note: This is not a complete chart of all invertebrates; it contains only common phyla, classes, and orders of stream benthic macroinvertebrates.

King

Phillip

Came

Over

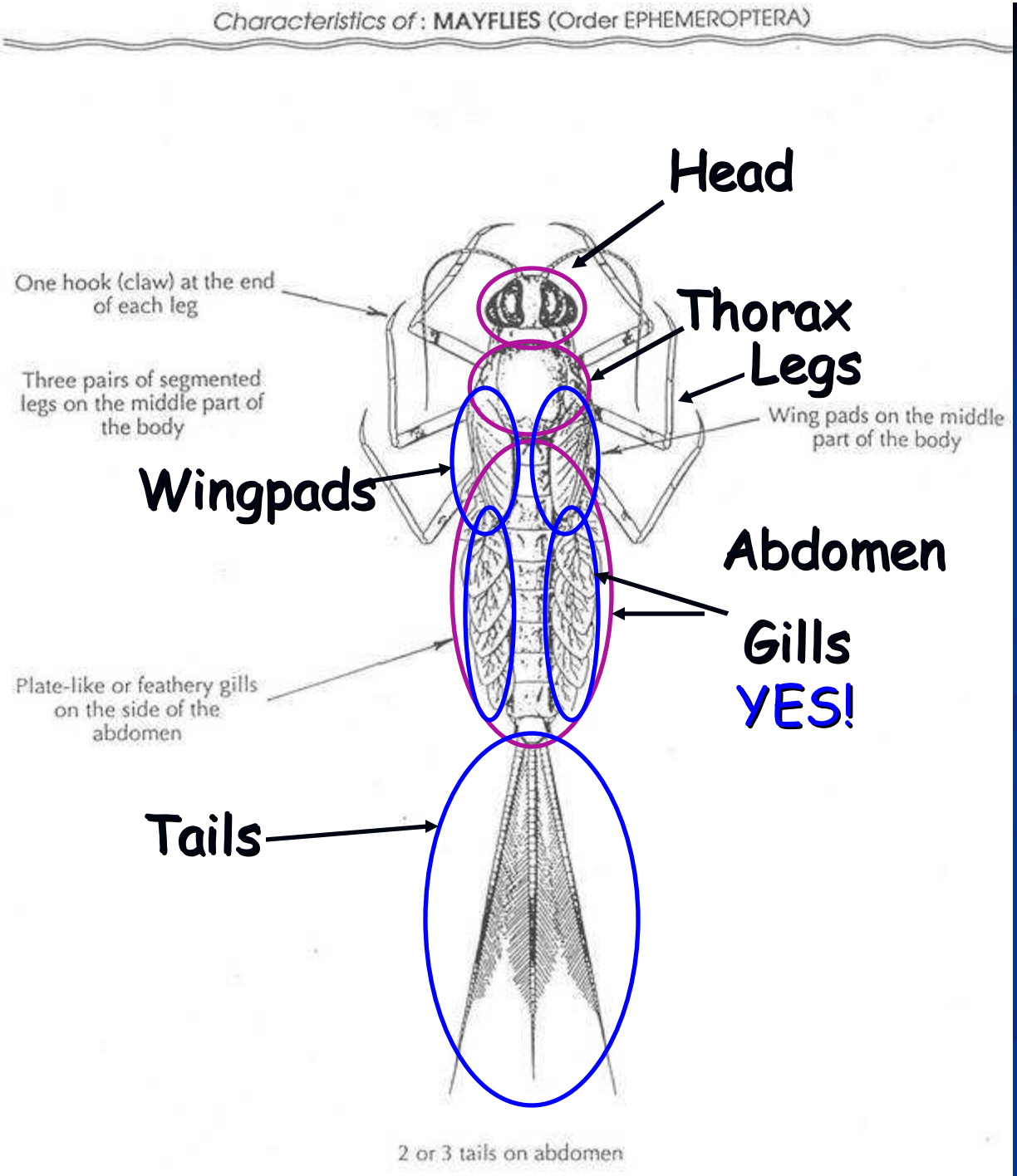
For

Great…

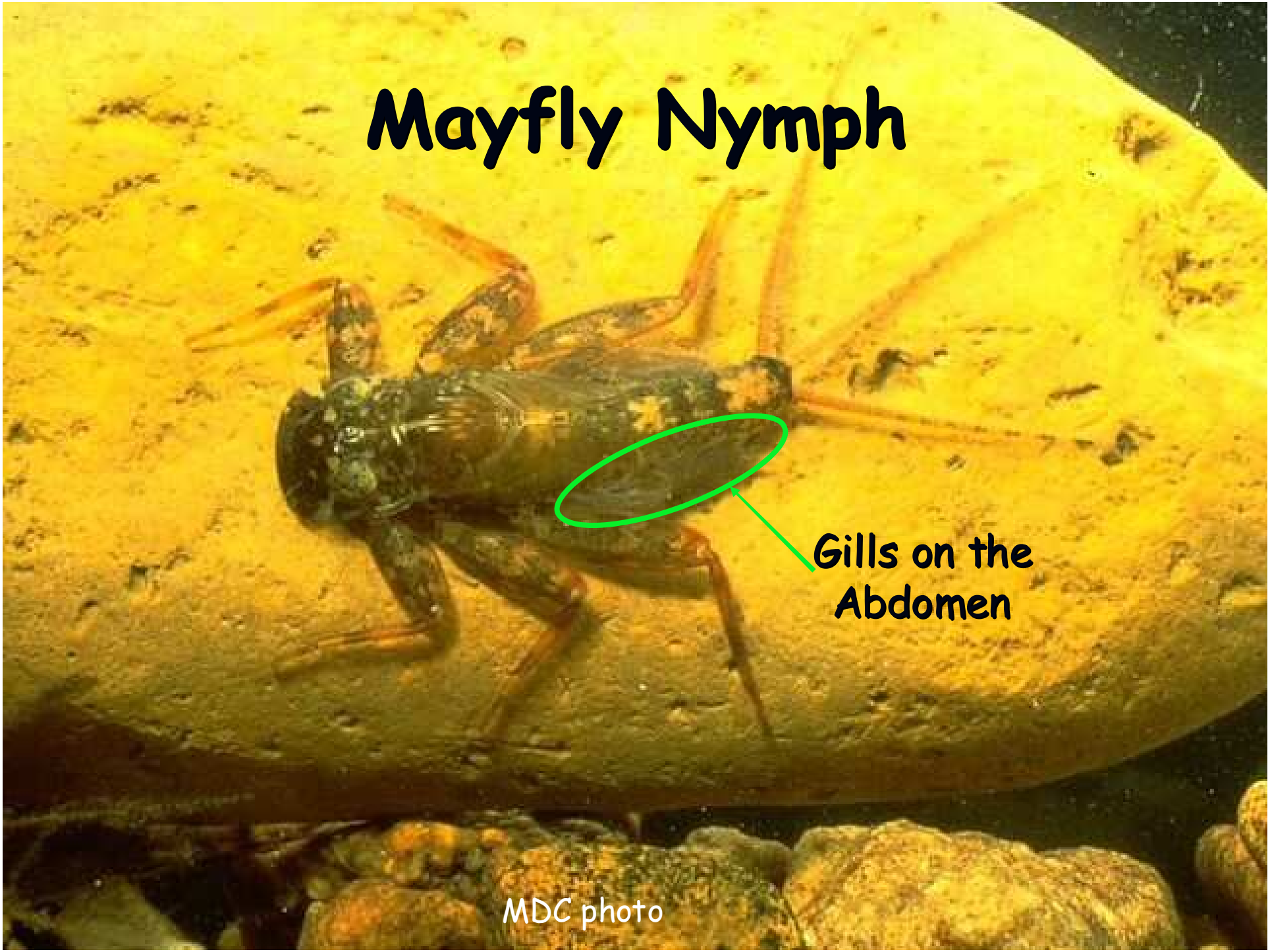
…**S**almon!

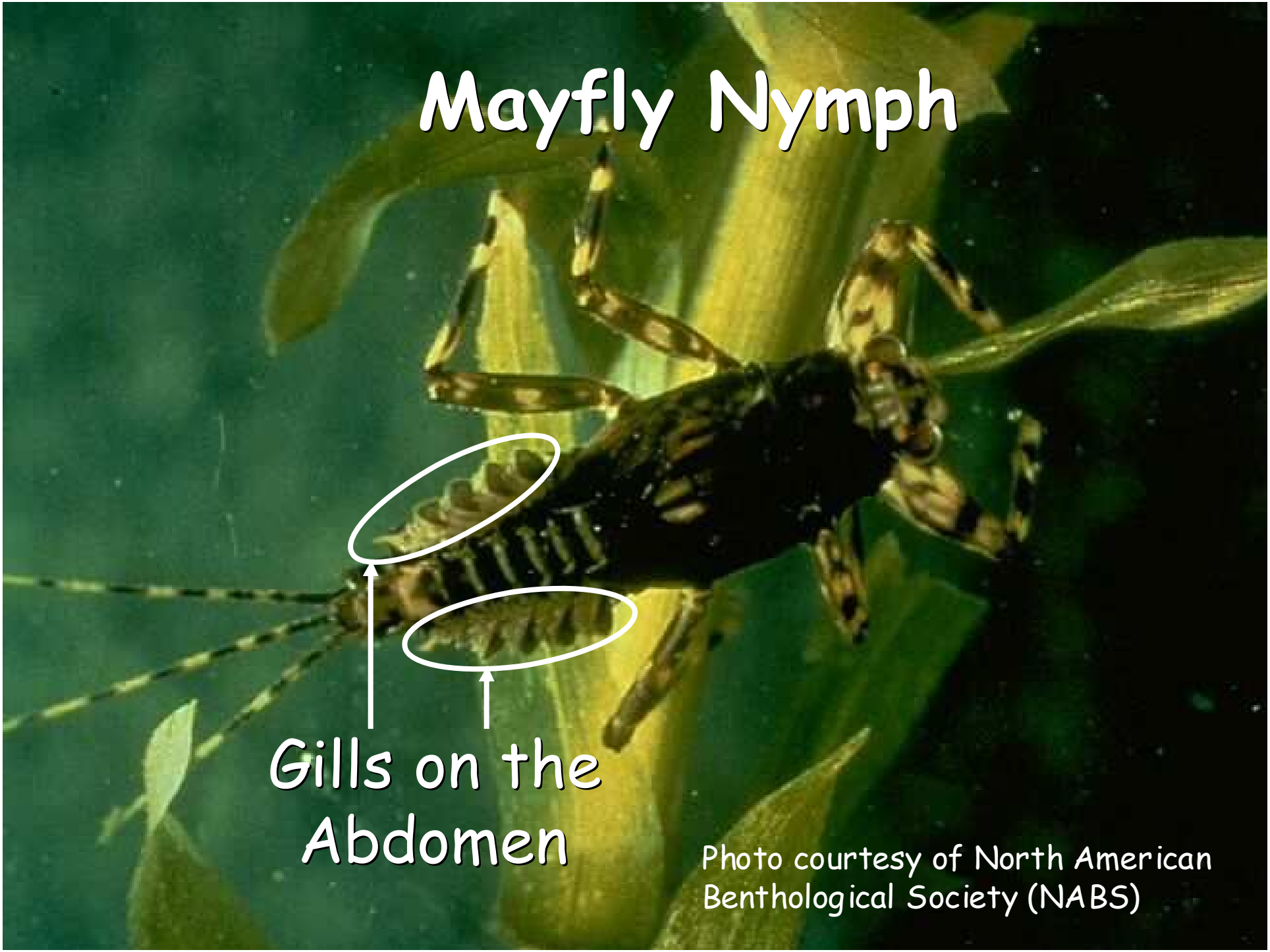
CATEGORIES OF POLLUTION TOLERANCE

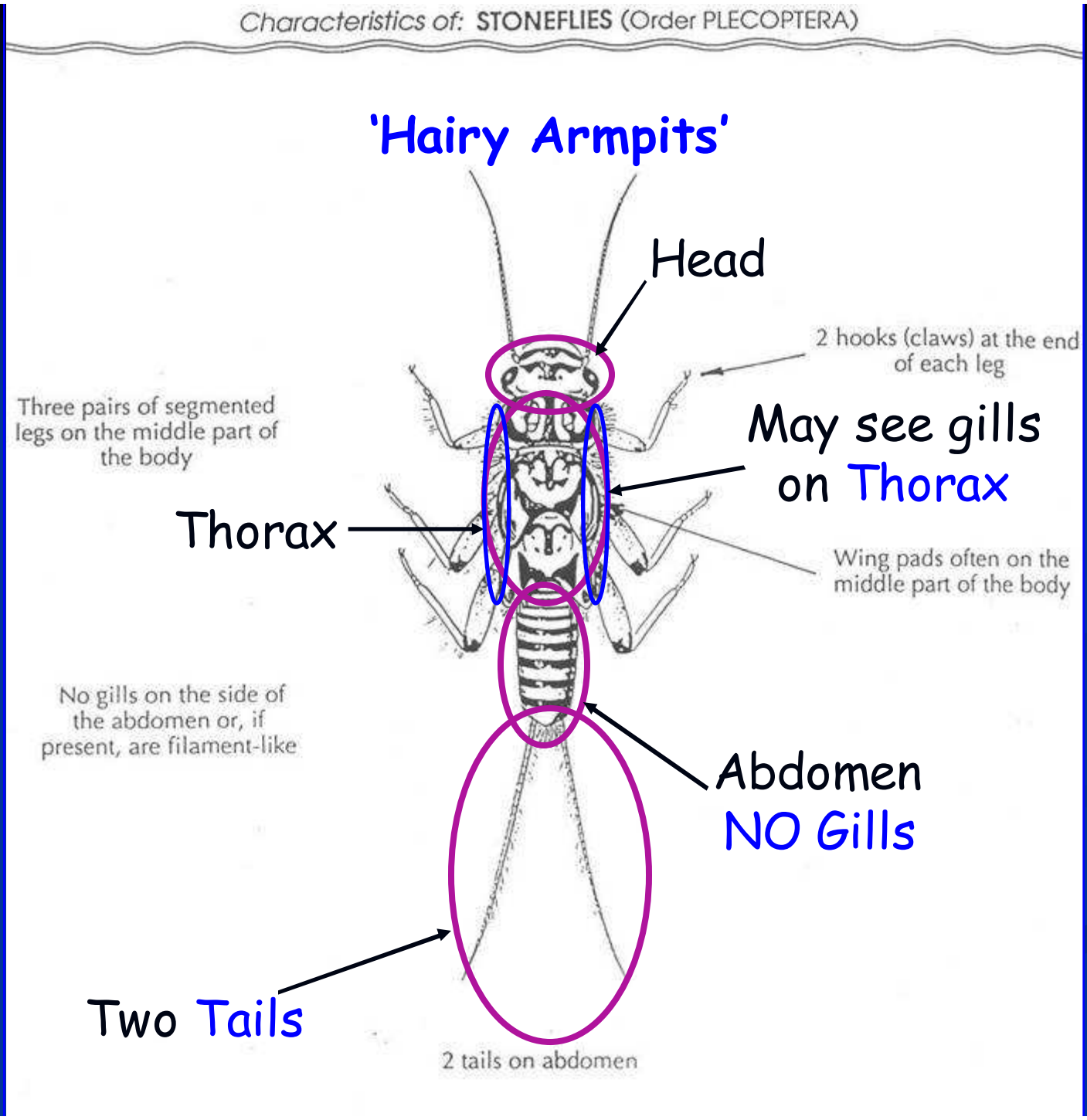
- Pollution Sensitive
- Somewhat Pollution Tolerant
- Pollution Tolerant

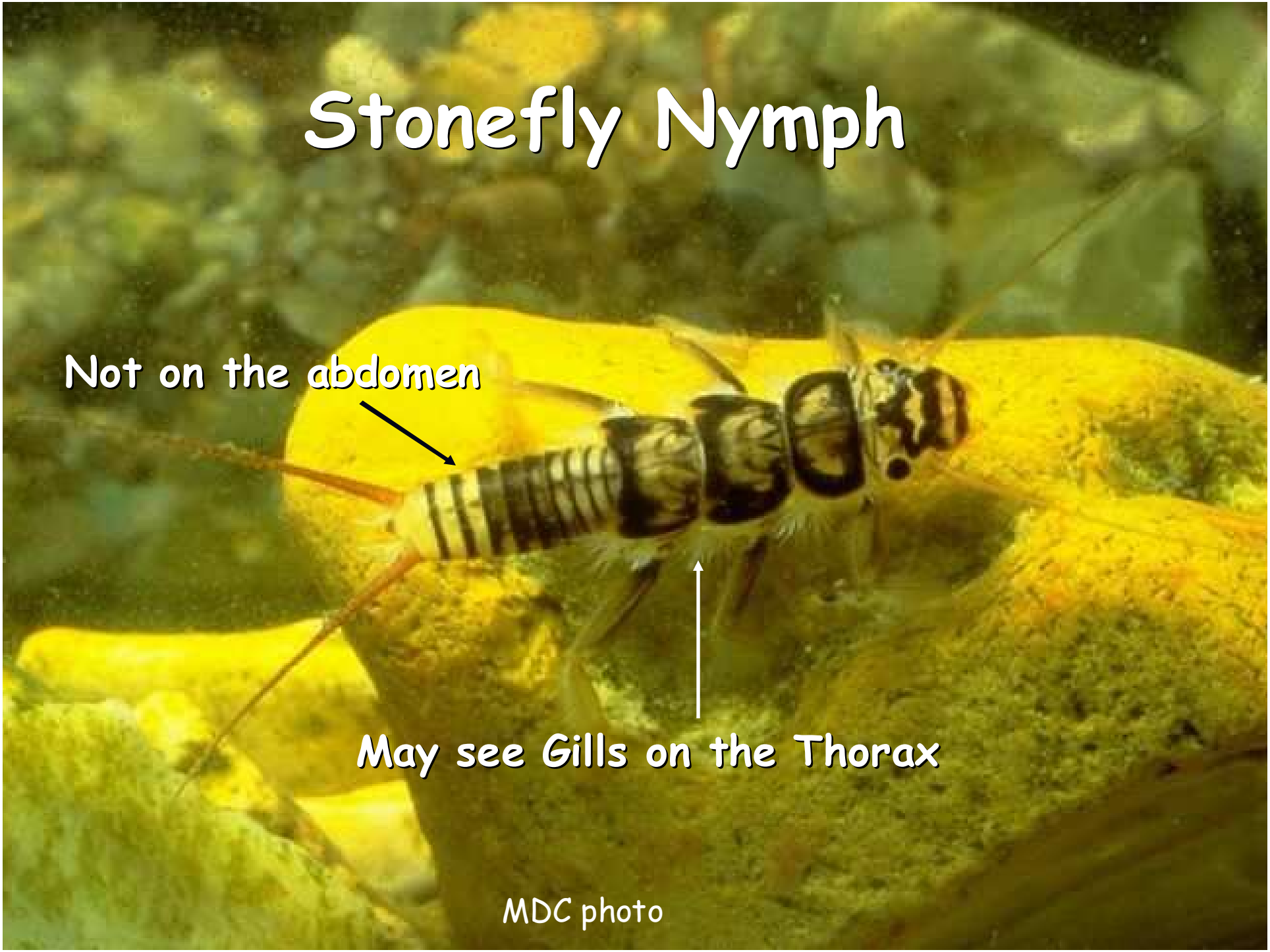

Characteristics of : MAYFLIES (Order EPHEMEROPTERA)
Head
Thorax
Legs
Wingpads
Abdomen
Gills
YES!
Tails
One hook (claw) at the end of each leg
Three pairs of segmented legs on the middle part of the body
Wing pads on the middle part of the body
Plate-like or feathery gills on the side of the abdomen
2 or 3 tails on abdomen

Mayfly Nymph

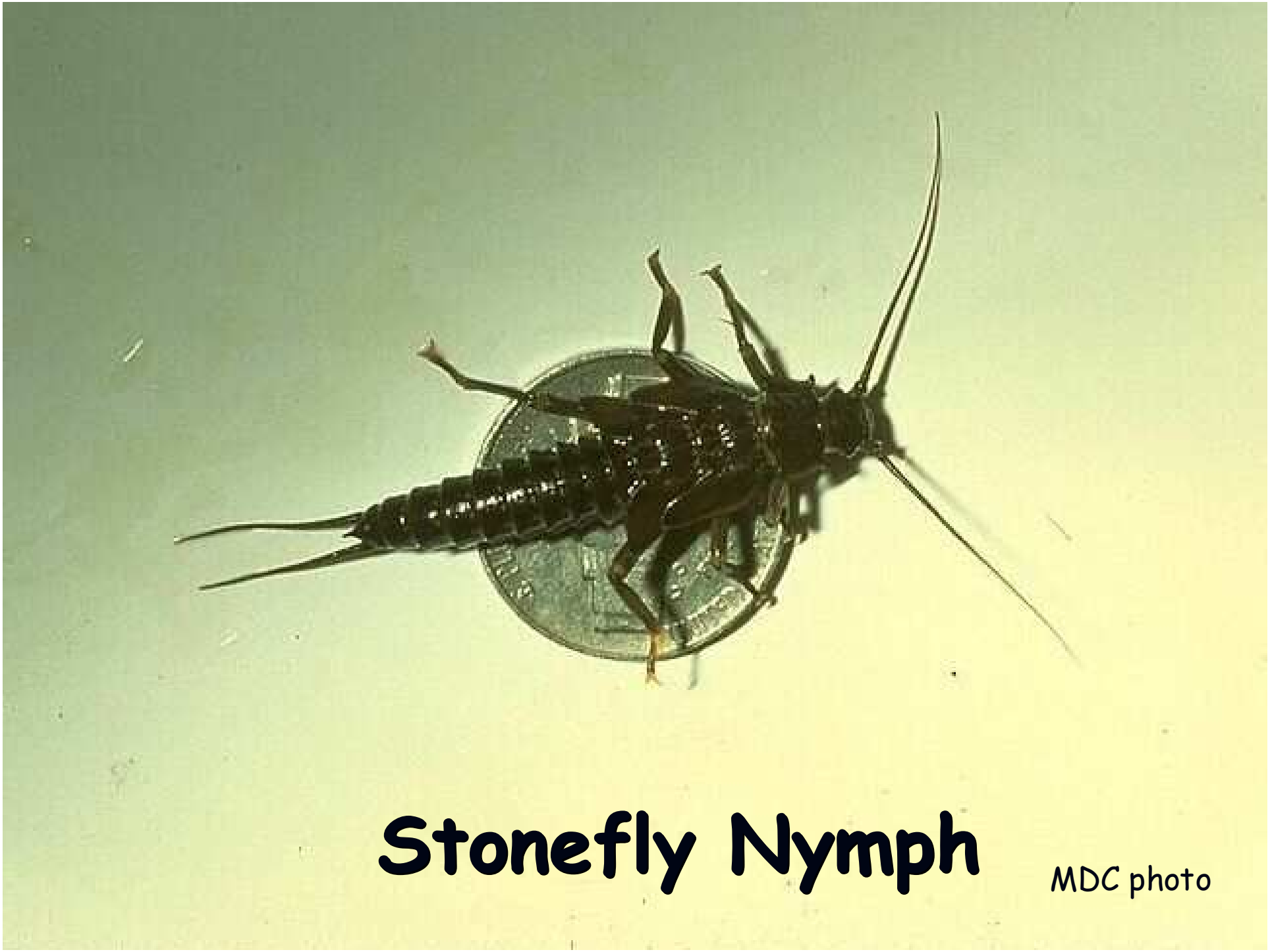



Mayfly Nymph
Gills on the Abdomen
Photo courtesy of North American Benthological Society (NABS)


Characteristics of: STONEFLIES (Order PLECOPTERA)
'Hairy Armpits'
Head
2 hooks (claws) at the end of each leg
Three pairs of segmented legs on the middle part of the body
May see gills on Thorax
Thorax
Wing pads often on the middle part of the body
No gills on the side of the abdomen or, if present, are filament-like
Abdomen
NO Gills
Two Tails
2 tails on abdomen

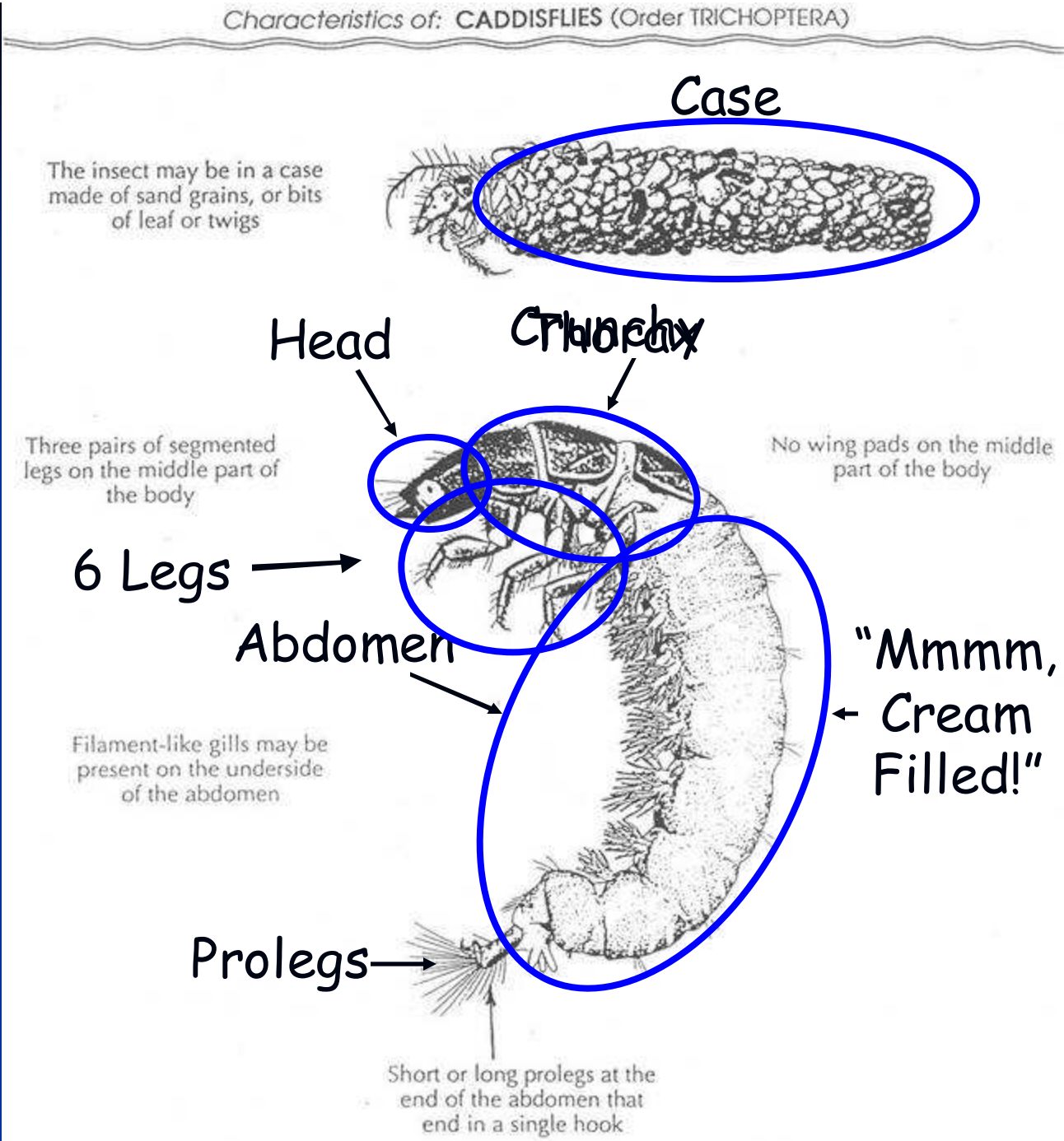

Stonefly Nymph
Not on the abdomen
May see Gills on the Thorax
MDC photo

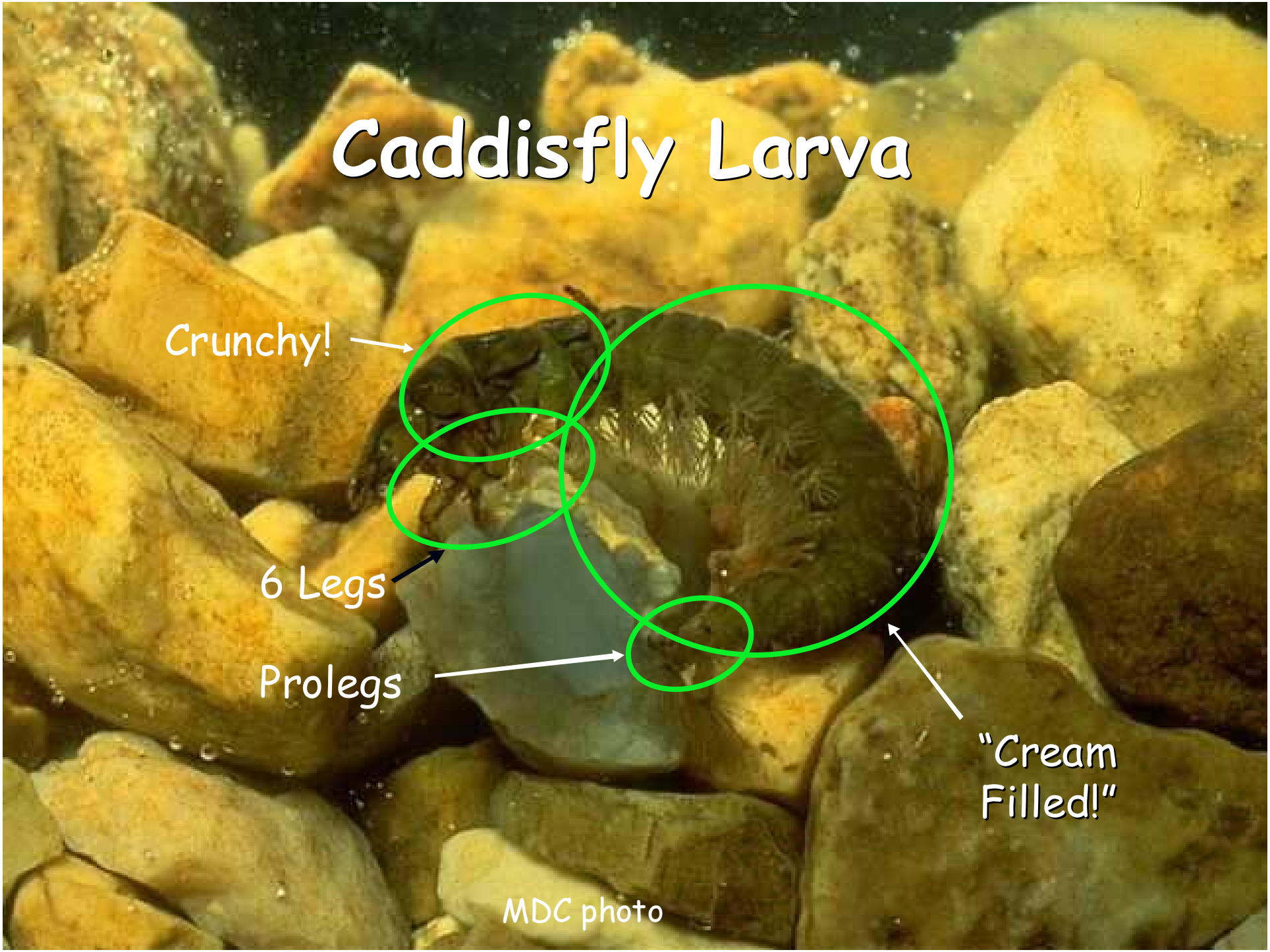

Stonefly Nymph
To Scale!!
Not on the abdomen
Gills on the Thorax
MDC photo



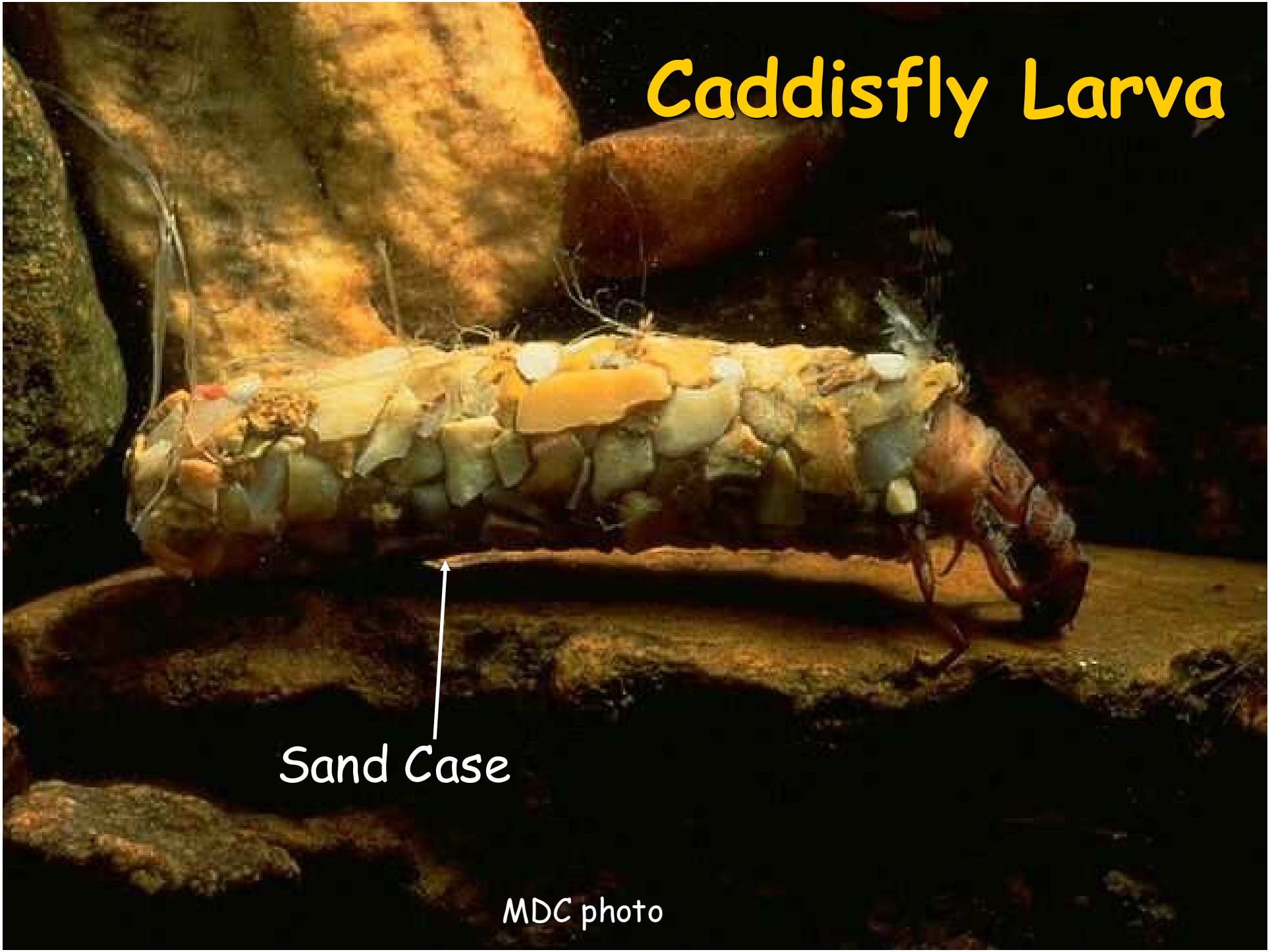
Stonefly Nymph

MDC photo

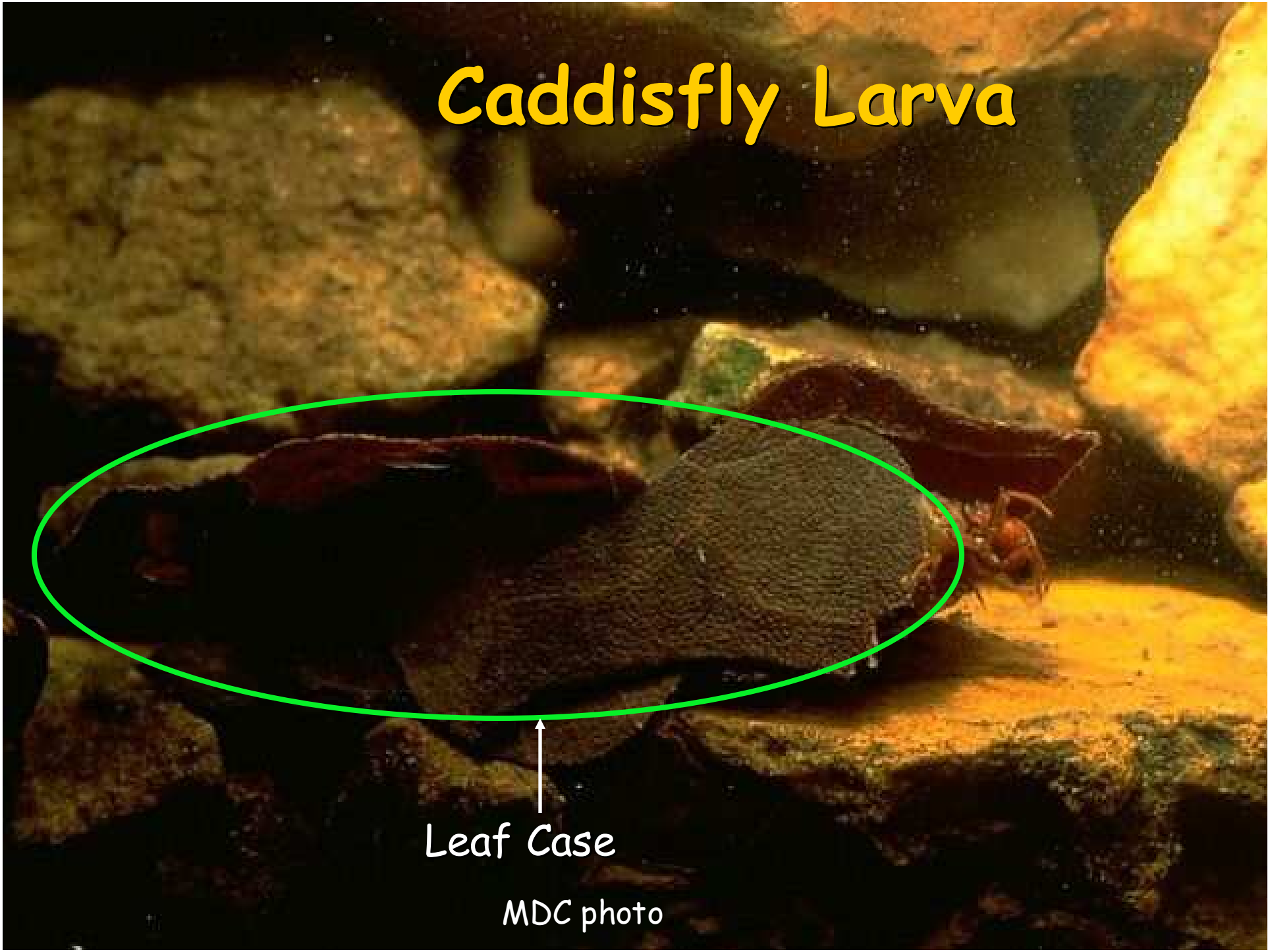

Characteristics of: CADDISFLIES (Order TRICHOPTERA)
Case
The insect may be in a case made of sand grains, or bits of leaf or twigs
Head
Crunchy
Three pairs of segmented legs on the middle part of the body
No wing pads on the middle part of the body
6 Legs
Abdomen
"Mmmm, Cream Filled!"
Filament-like gills may be present on the underside of the abdomen
Prolegs
Short or long prolegs at the end of the abdomen that end in a single hook


Caddisfly Larva
Crunchy!
6 Legs
Prolegs
"Cream Filled!"
MDC photo

Caddisfly Larva



MDC photo

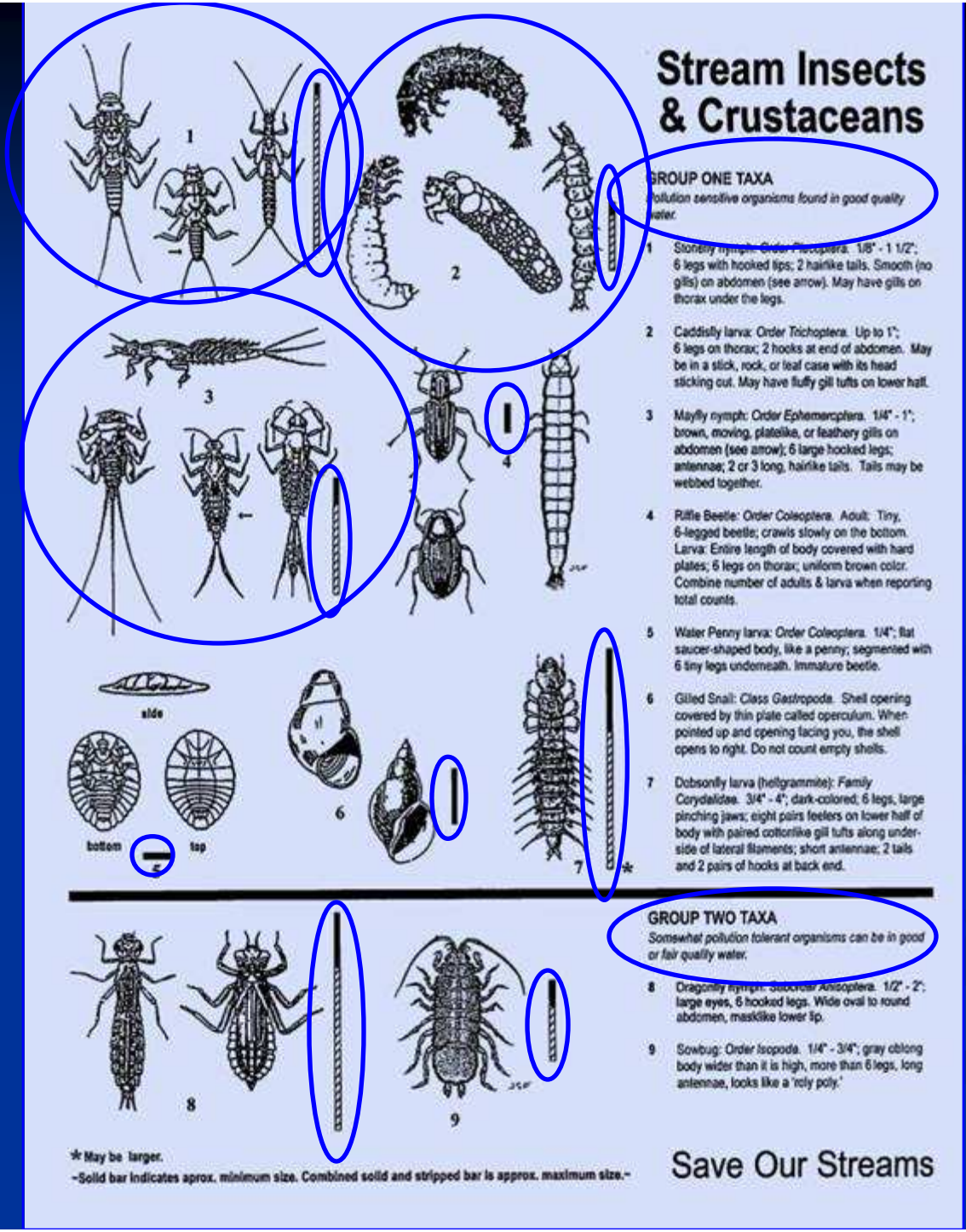

Caddisfly Larva
Leaf Case
MDC photo

Caddisfly Larva

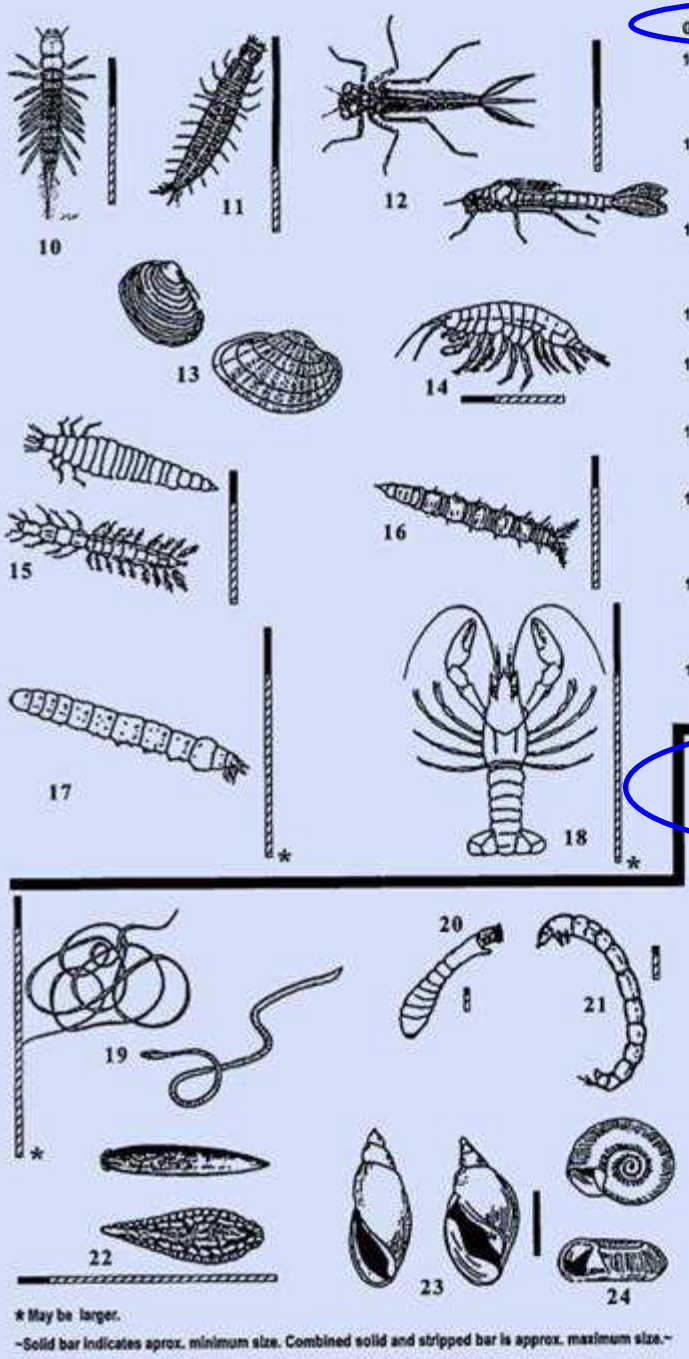
Caddisfly jewelry created by French artist Hubert Duprat

Jewel Case?

Blue Bug Card (front)



Blue Bug Card (back)



GROUP TWO TAXA continued

10 Alderfly larva: *Family Sialidae*. 3/8"- 1"; looks like small hellgrammite but has 1 long, thin, branched tail at end of abdomen (no hooks). No gill tuft underneath the lateral filaments on abdomen.

11 Fishfly larva: *Family Corydalidae*. Up to 1 1/2"; lateral filaments on abdomen. Looks like small hellgrammite but often a lighter reddish-tan color, or with yellowish streaks. No gill tufts underneath.

12 Damselfly nymph: *Suborder Zygoptera*. 1/2"- 1"; large eyes; 6 thin hooked legs; 3 broad oar-shaped tails; body positioned like a tripod. Smooth (no gills) on sides of lower half of body (see arrow).

13 Clam/Mussel: *Class Bivalvia*. Do not count empty shells.

14 Scud: *Order Amphipoda*. 1/4"- 3/4"; white to gray, body higher than it is wide; swims sideways; more than 6 legs; resembles small shrimp.

15 Other Beetle larva: *Order Coleoptera*. 1/4" - 1"; light-colored; 6 legs on upper half of body; feelers; antennae; obvious mouthparts. Diverse group.

16 Watersnipe Fly larva: *Family Athericidae (Atherix)*. 1/4" - 1"; pale to green; tapered body; many caterpillarlike legs; conical head; two feathery 'horns' at back end.

17 Crane Fly larva: *Suborder Nematocera*. 1/3" - 4"; milky, green, or light brown; plump caterpillarlike segmented body. May have enlarged lobe or fleshy fingerlike extensions at the end of the abdomen.

18 Crayfish: *Order Decapoda*. Up to 6"; 2 large claws, 8 legs, resembles small lobster.

GROUP THREE TAXA

Pollution tolerant organisms can be in any quality of water.

19 Aquatic Worm/Horsehair Worm: *Class Oligochaeta/ Phylum Nematomorpha*. Aquatic worm: 1/4"- 2"; can be very tiny, thin wormlike body. Horsehair Worm: 4"-27"; slender, can be tangled.

20 Black Fly larva: *Family Simulidae*. 1/8"- 3/8"; one end of body wider. Black head, suction pad on end.

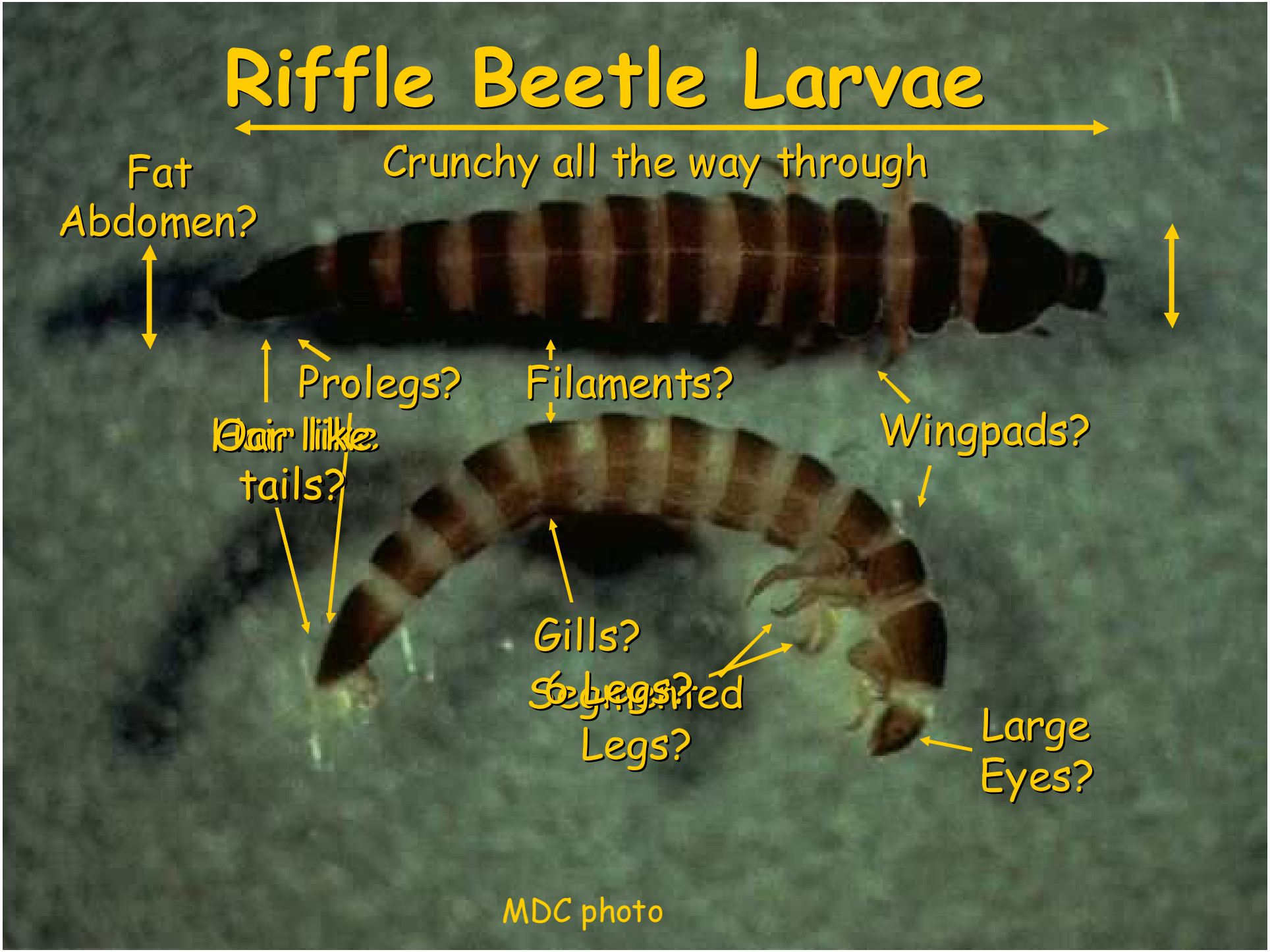
21 Midge Fly larva: *Suborder Nematocera*. Less than 1/4"; distinct head; wormlike segmented body; pair of tiny pro-legs under head and tip of abdomen.

22 Leech: *Order Hirudinea*. 1/4" - 2"; flattened muscular body, ends with suction pads.

23 Pouch Snail and Pond Snails: *Class Gastropoda*. No operculum. Breathe air. Shell usually opens on left. Do not count empty shells.

24 Other snails: *Class Gastropoda*. No operculum. Breathe air. Snail shell coils in one plane. Do not count empty shells.

09/07
STR 250

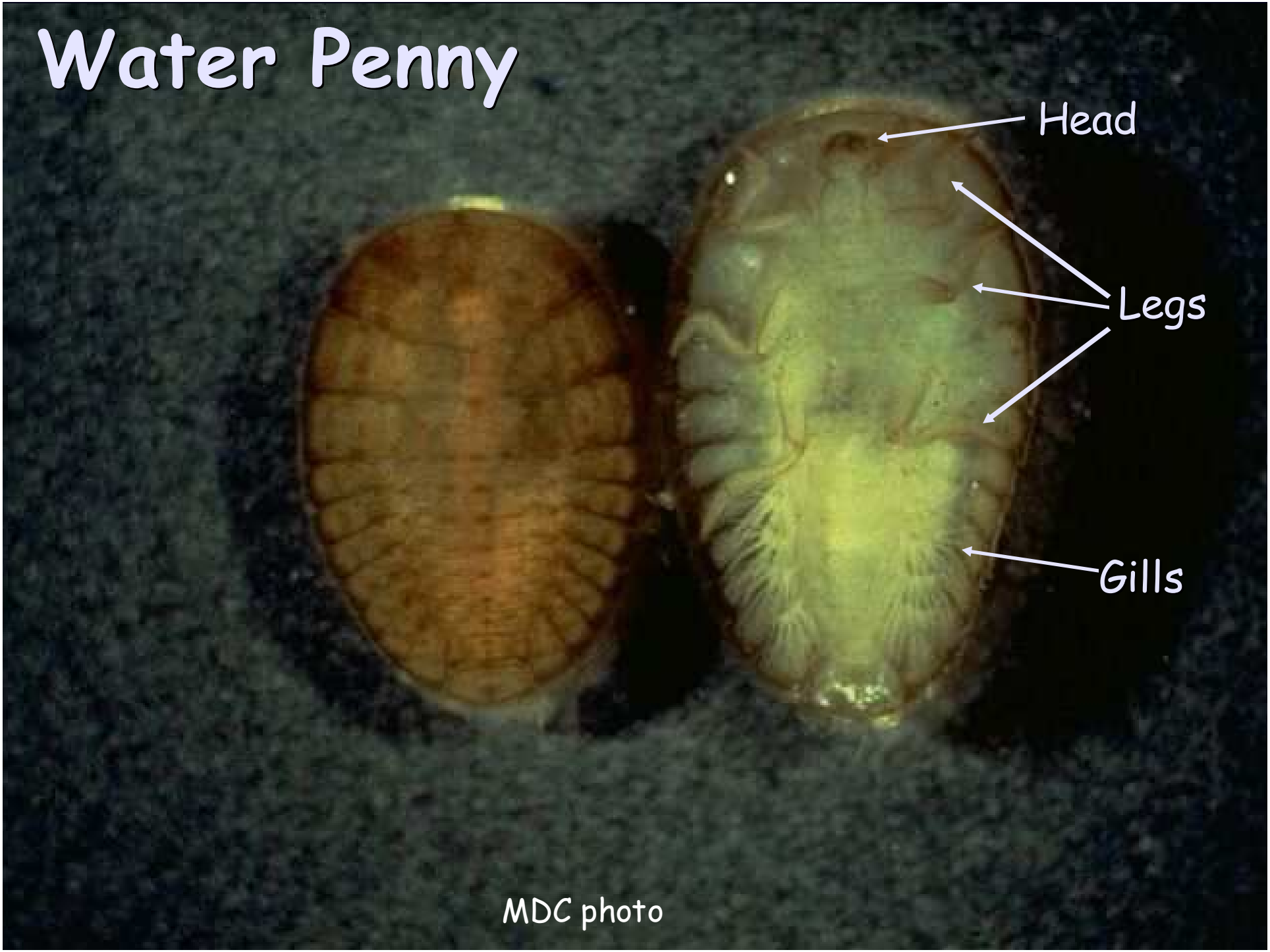

Riffle Beetle Larvae
Crunchy all the way through
Fat Abdomen?
Prolegs?
Filaments?
Wingpads?
Hair like tails?
Gills?
6 Segmented Legs?
Large Eyes?
MDC photo

Riffle Beetle Adult

MDC photo

Water Penny

MDC photo


Water Penny
Head
Legs
Gills
MDC photo

Water Penny

MDC photo

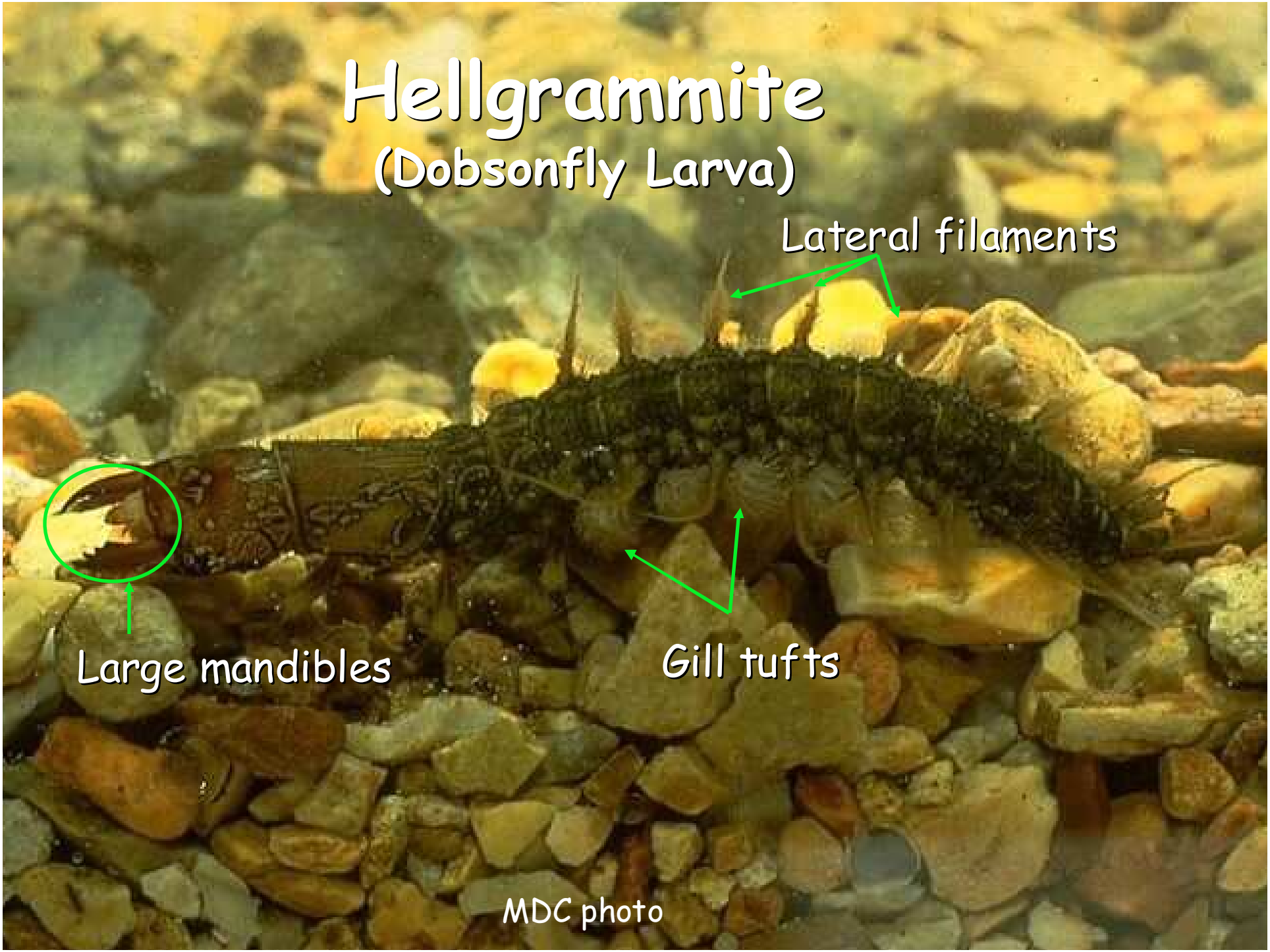
Gilled Snail

MDC photo

Gilled Snail

Opening to the right

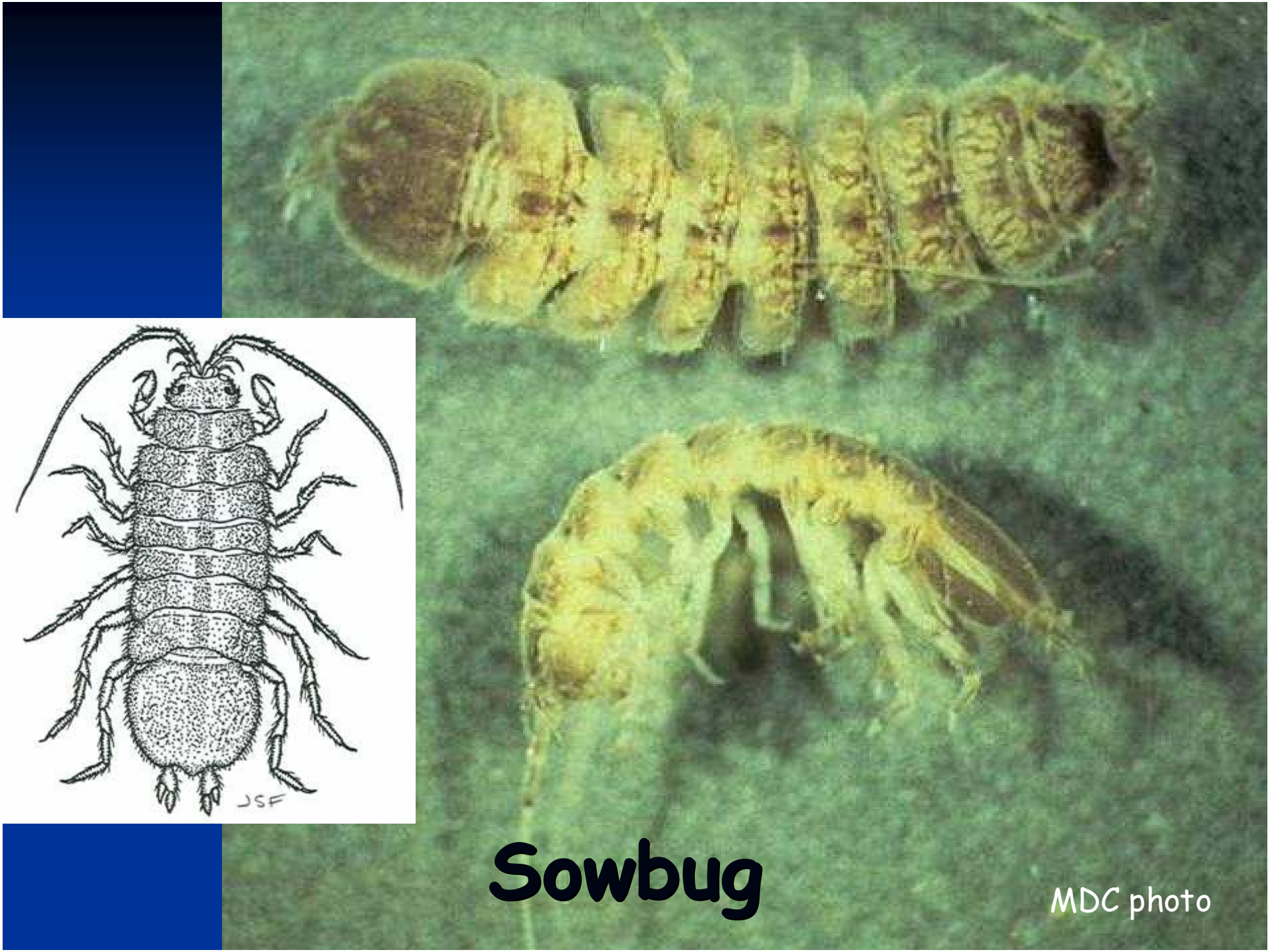
MDC photo


Hellgrammite
(Dobsonfly Larva)
Lateral filaments
Large mandibles
Gill tufts
MDC photo

"Somewhat Tolerant" Category Crayfish

MDC photo

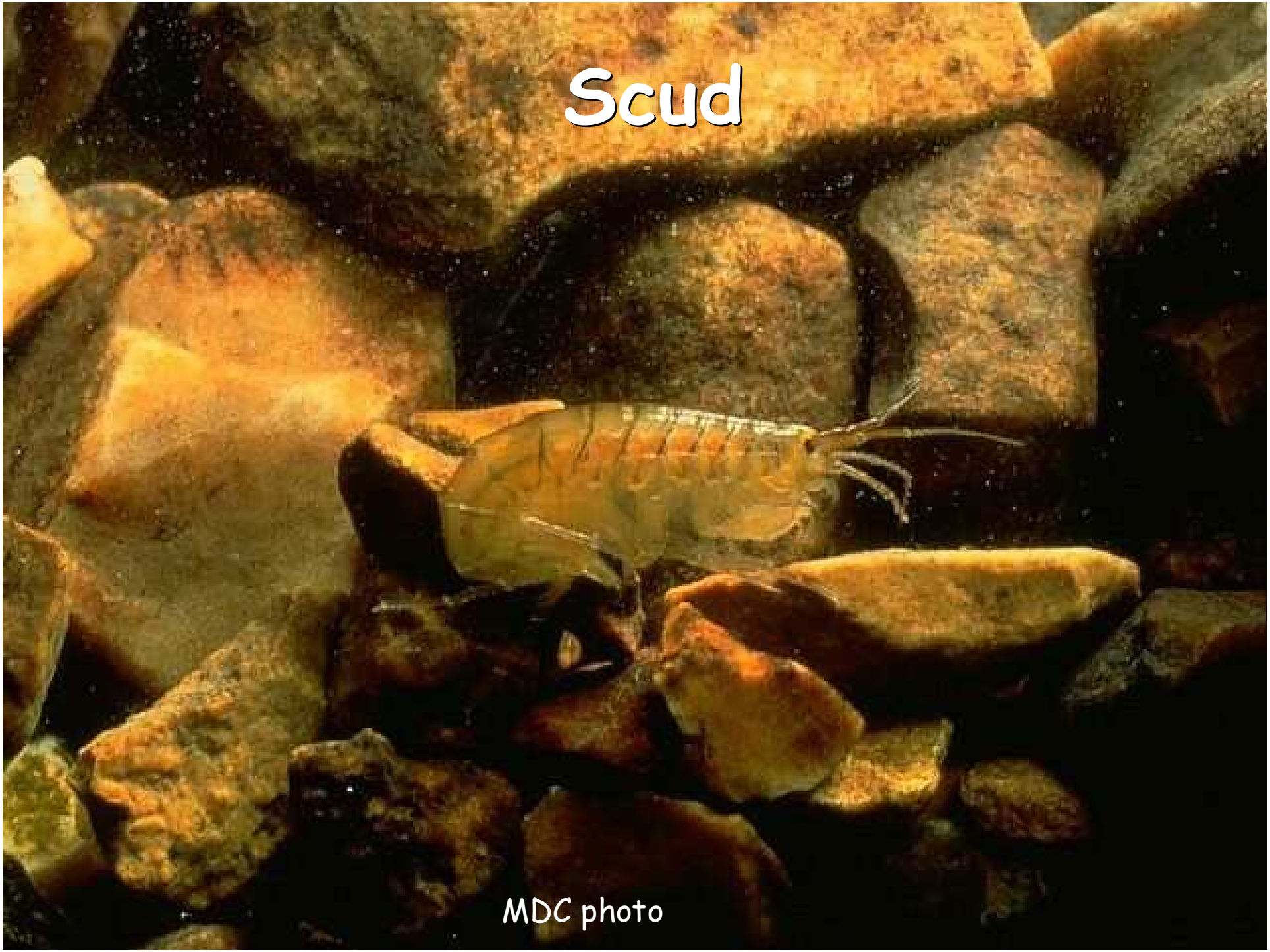

Sowbug
MDC photo



Sowbug

MDC photo

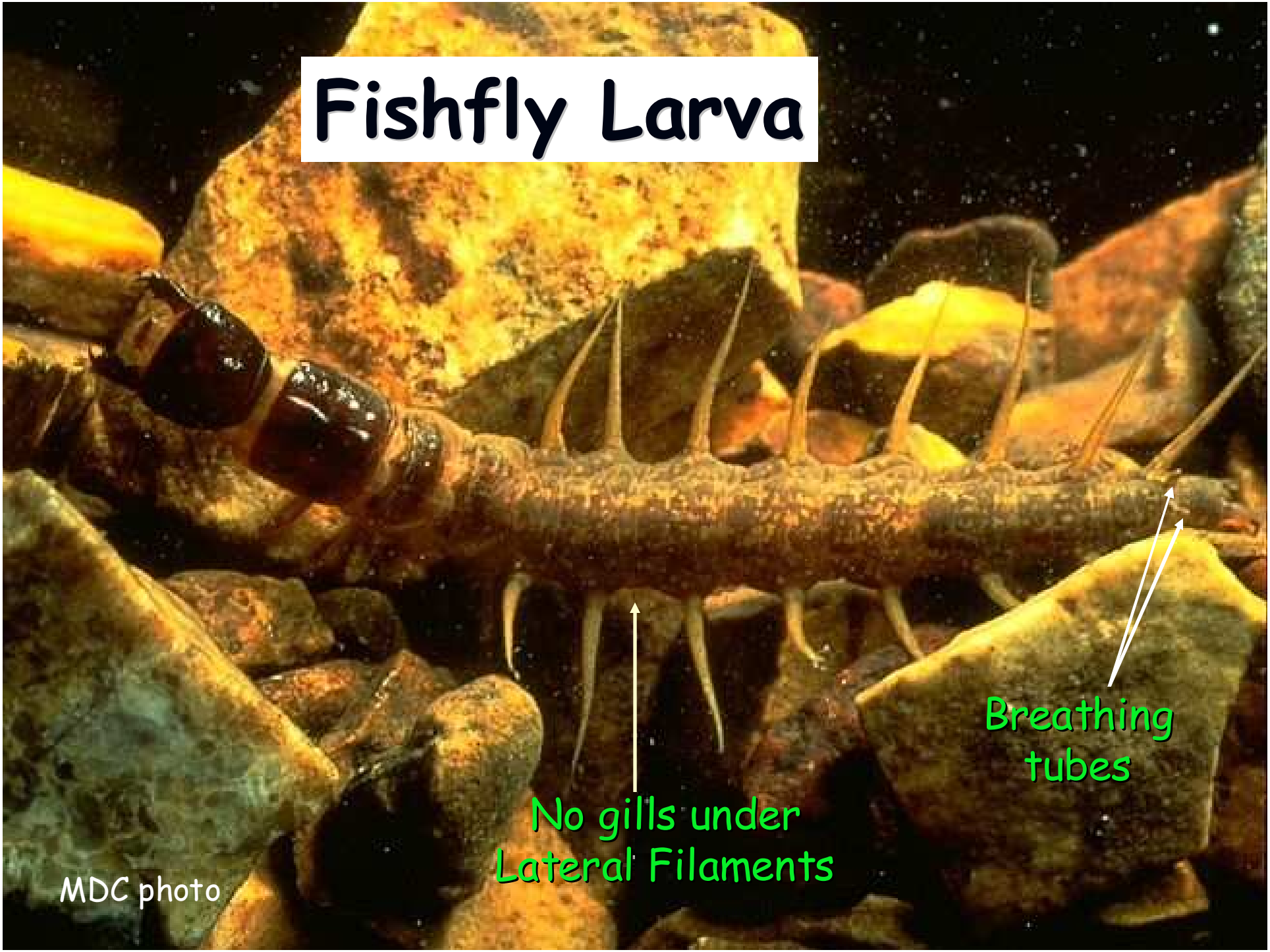
Scud



MDC photo


"Pickled" Scud
MDC photo

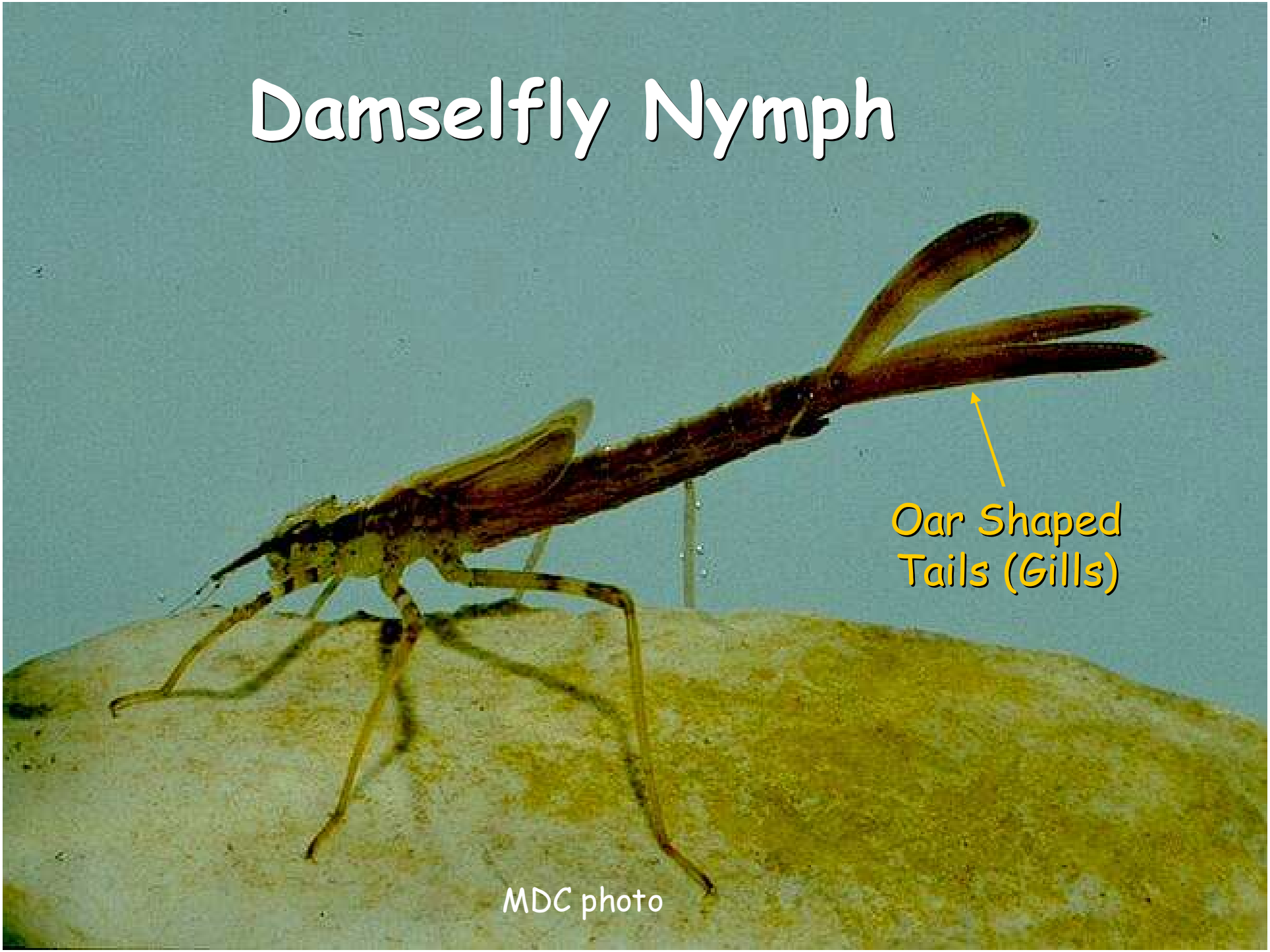
Alderfly Larva


Fishfly Larva
Breathing tubes
No gills under Lateral Filaments
MDC photo

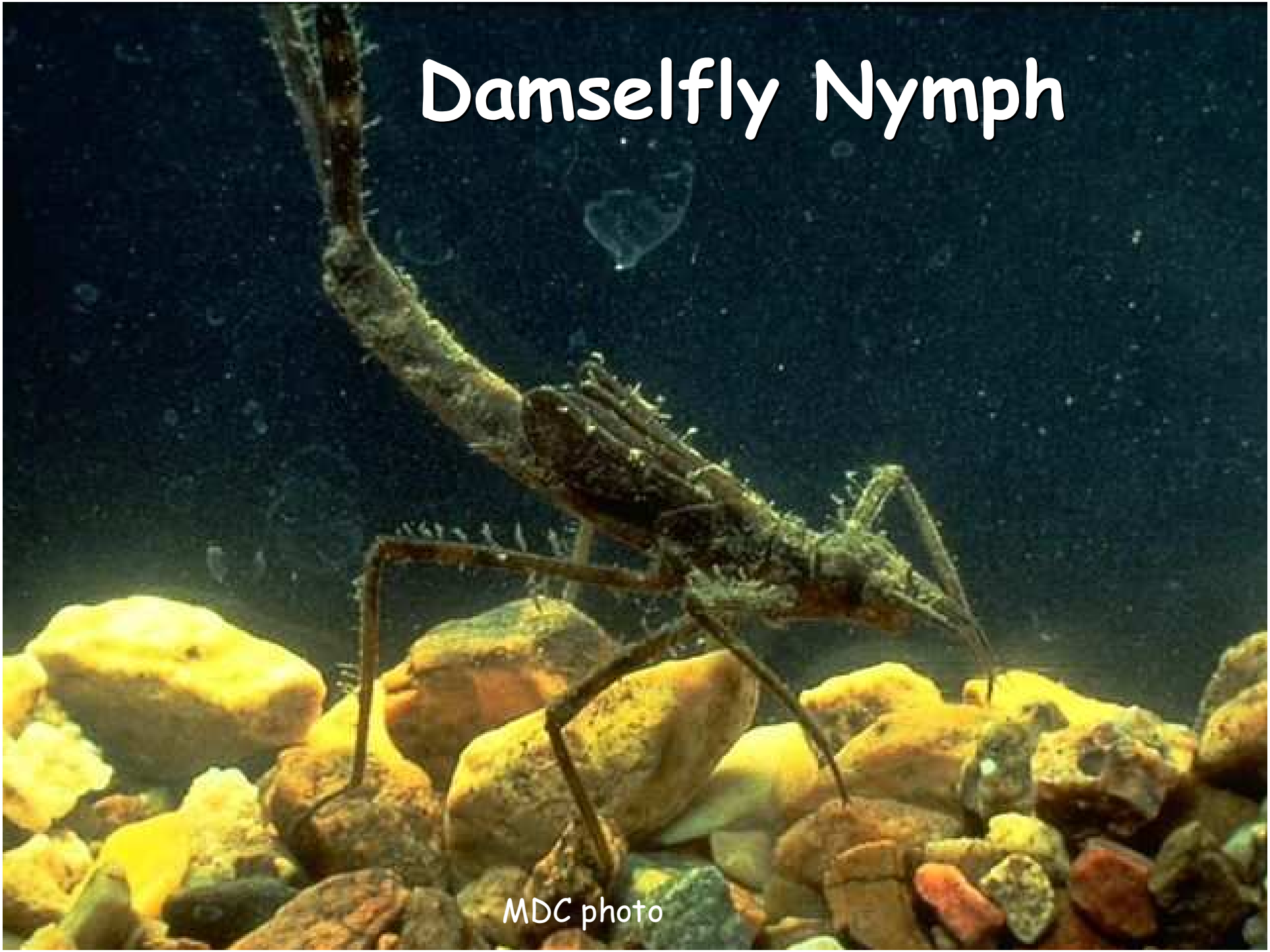
Fishfly Larva

MDC photo

Damselfly Nymph



Damselfly Nymph



MDC photo

Watersnipe Fly Larva

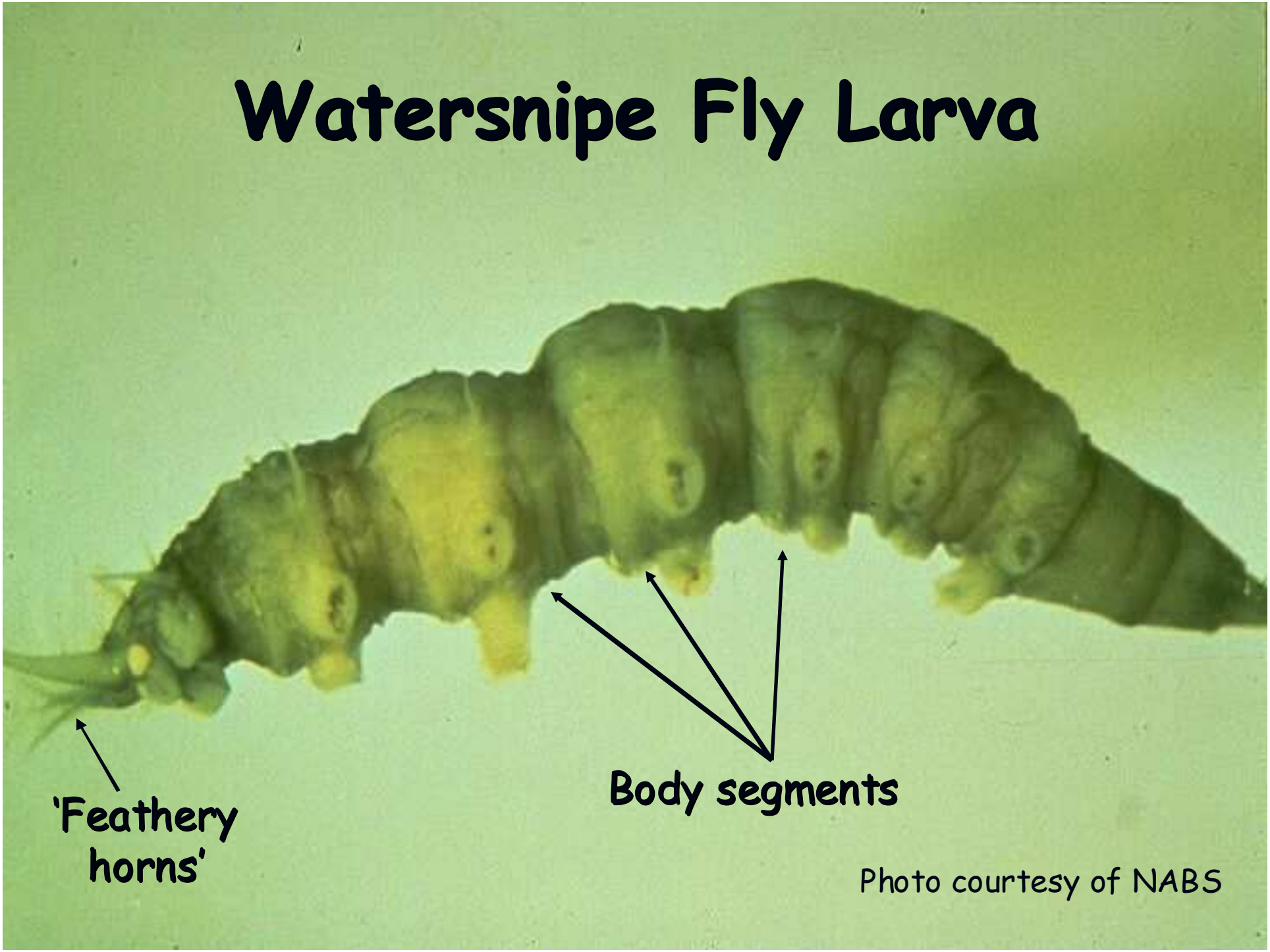


Photo courtesy of NABS

Crane Fly Larva

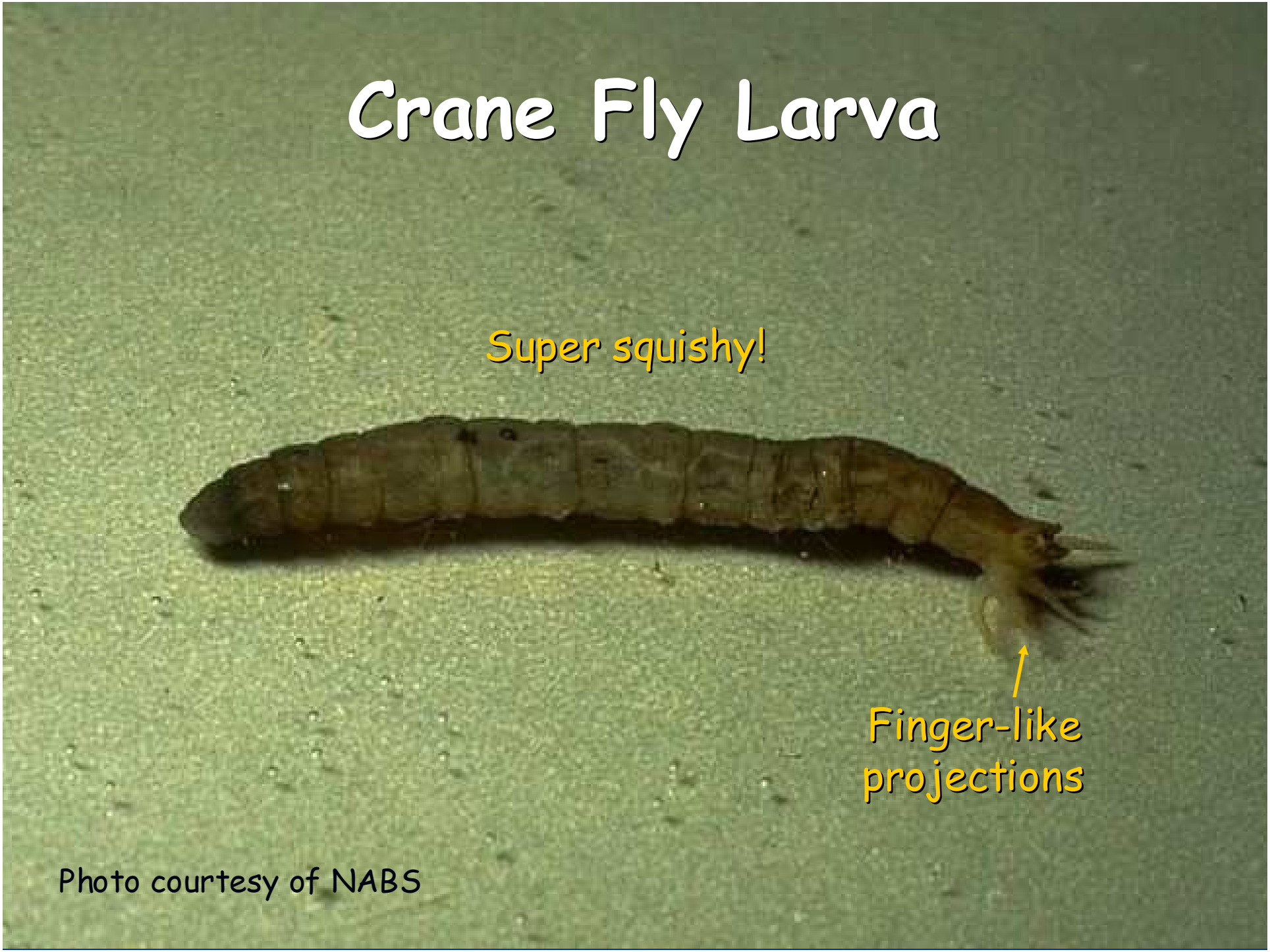


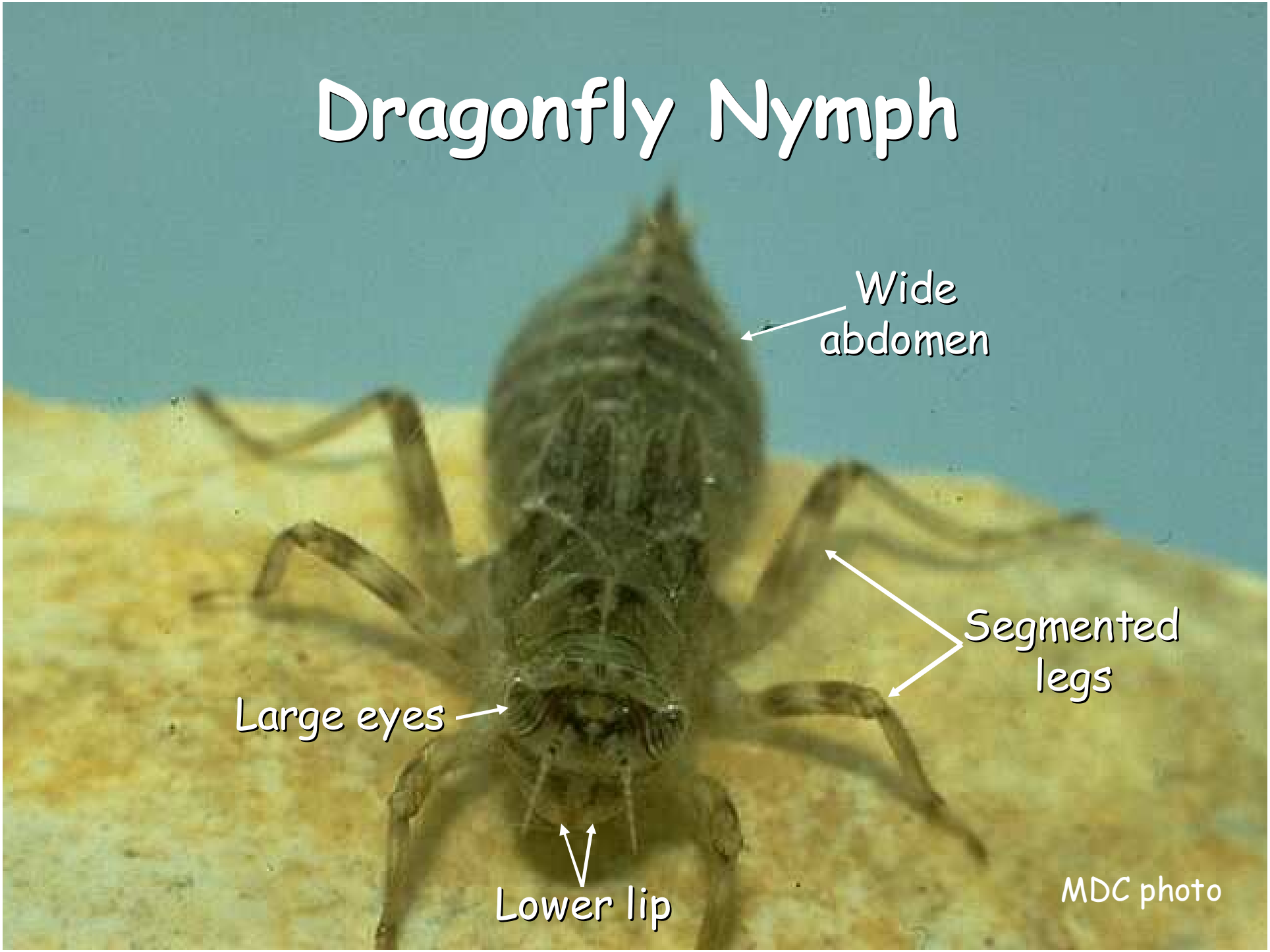
Photo courtesy of NABS

"Other Beetle Larva"

Many different types!!!

Process of elimination

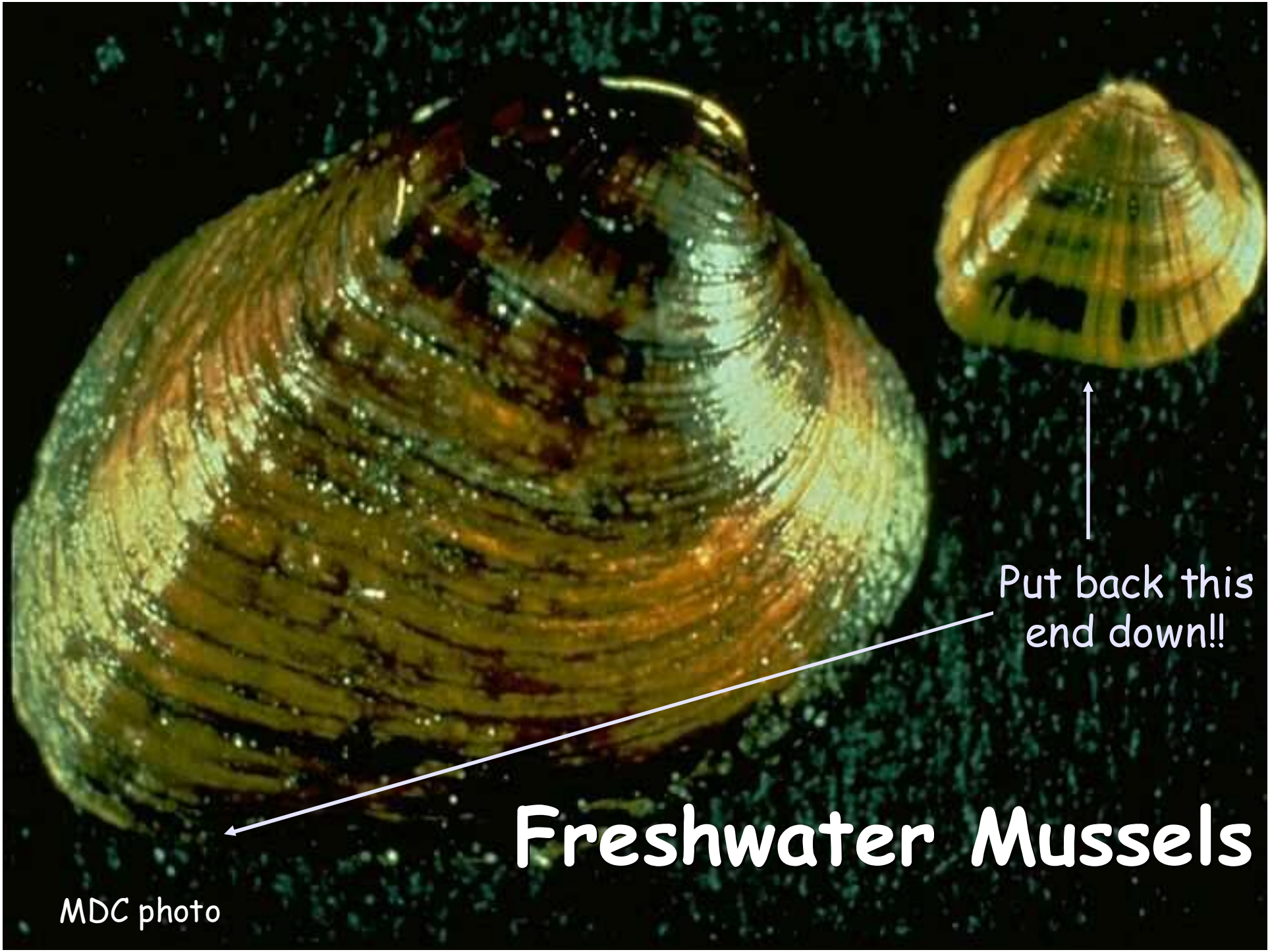
Photo courtesy of NABS


Dragonfly Nymph
Wide abdomen
Segmented legs
Large eyes
Lower lip
MDC photo


Dragonfly
Nymph
MDC photo

Dragonfly Nymph

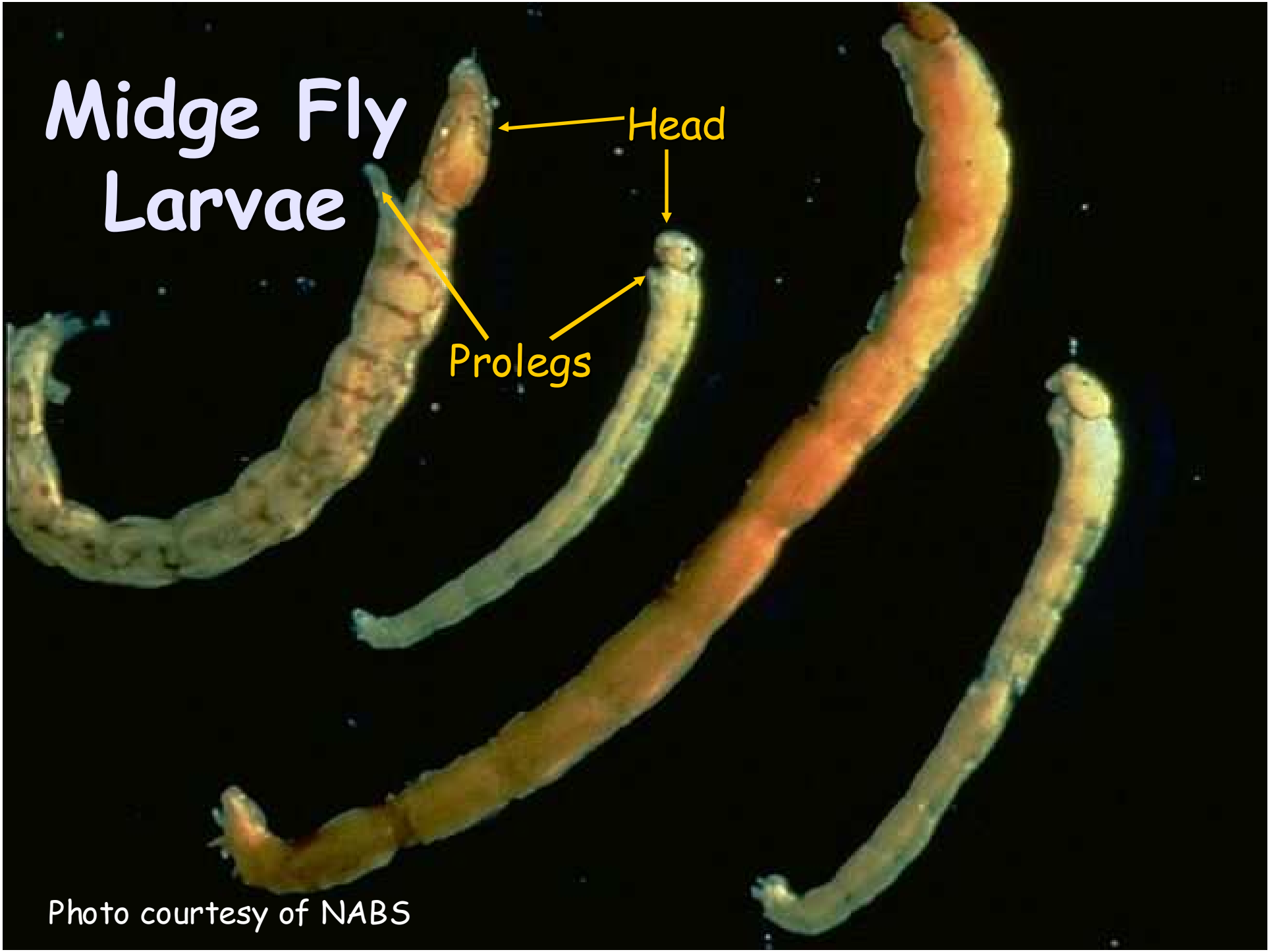
MDC photo

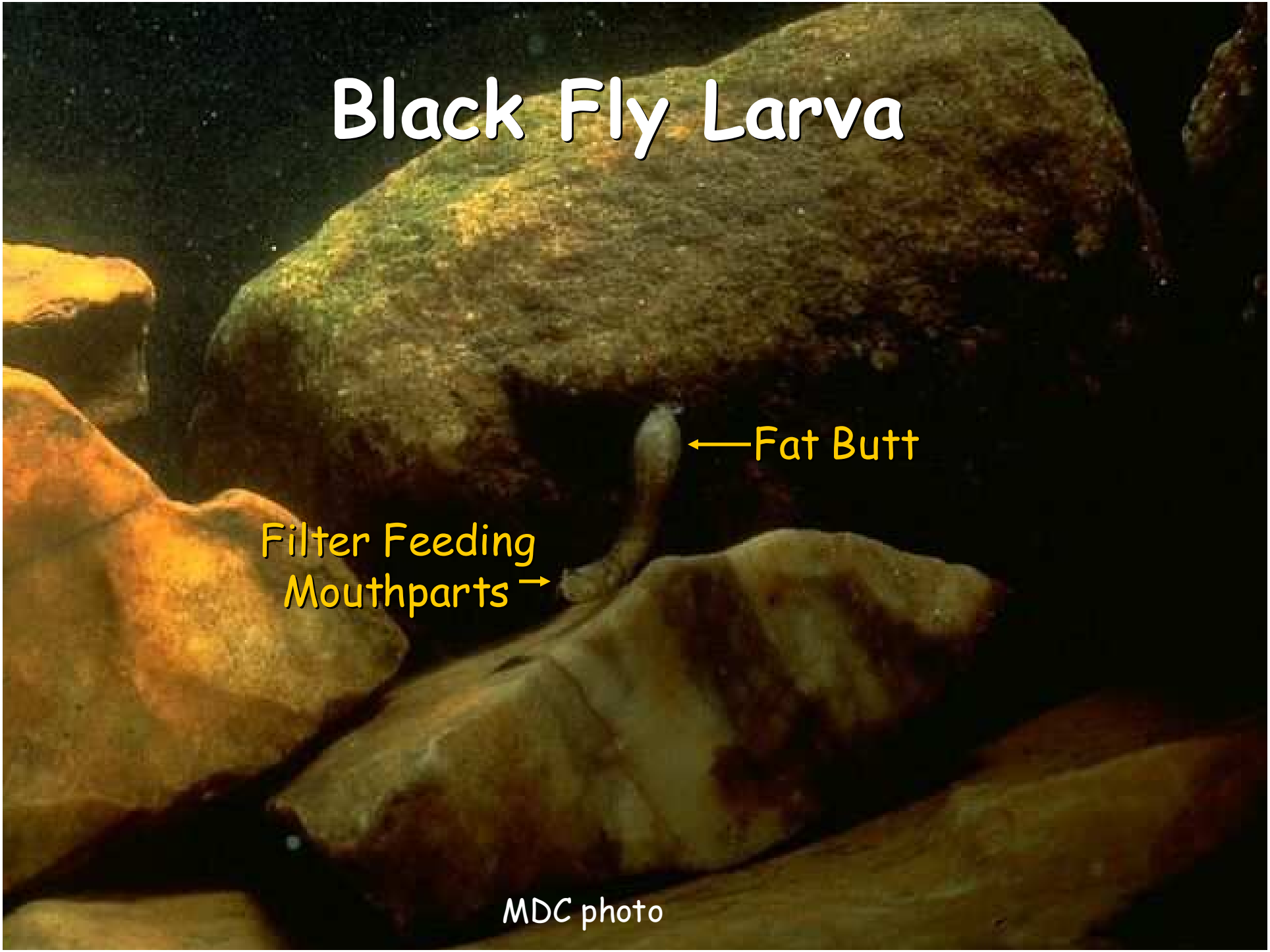

Put back this
end down!!
Freshwater Mussels
MDC photo

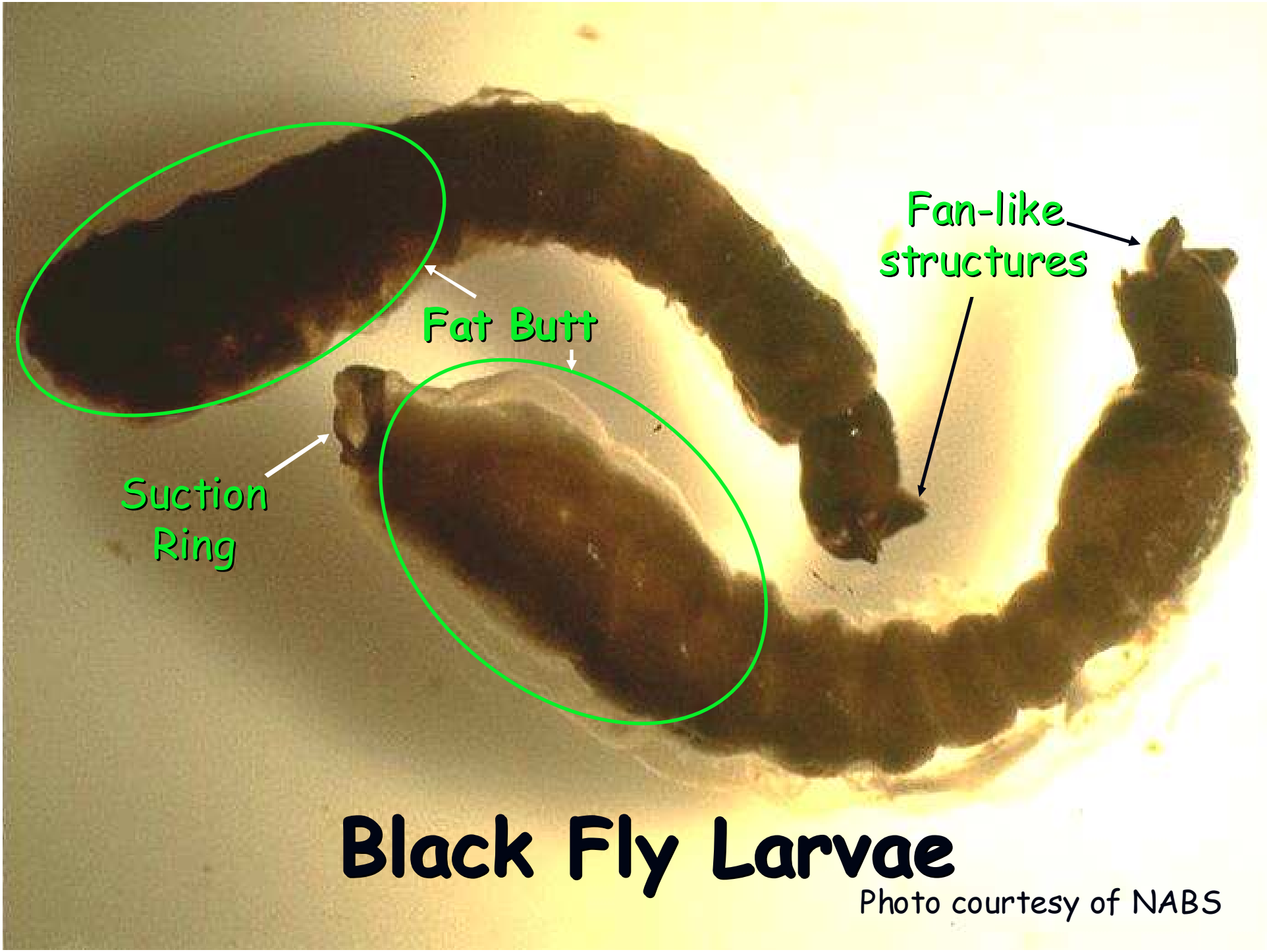

"Tolerant" Category
Aquatic Worm
(Aquatic Earthworm)
MDC photo


Aquatic Worm
(Horsehair Worm)
MDC photo


Midge Fly Larva
(Bloodworm)
MDC photo

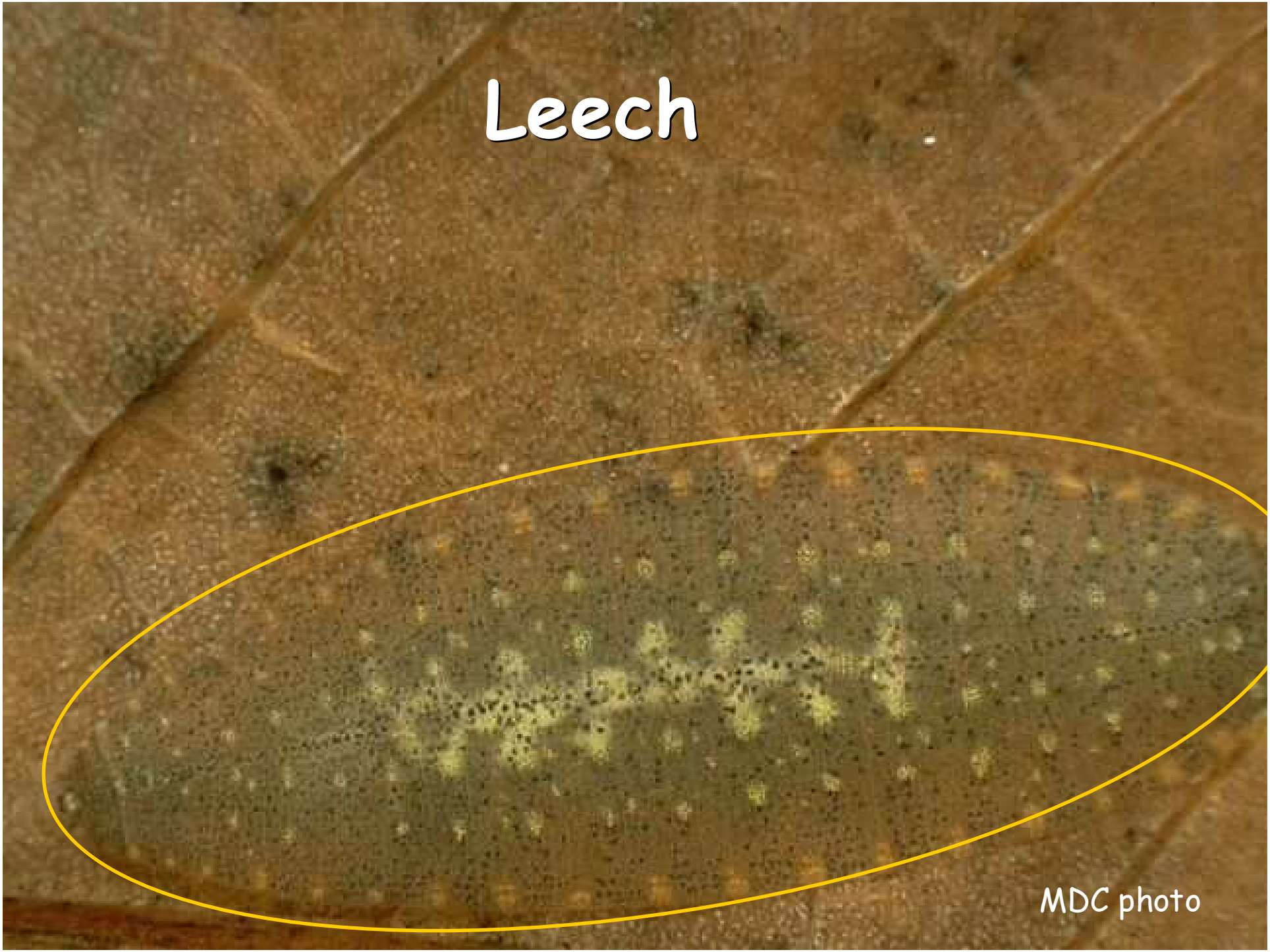

Midge Fly Larvae
Head
Prolegs
Photo courtesy of NABS


Black Fly Larva
←Fat Butt
Filter Feeding
Mouthparts →
MDC photo

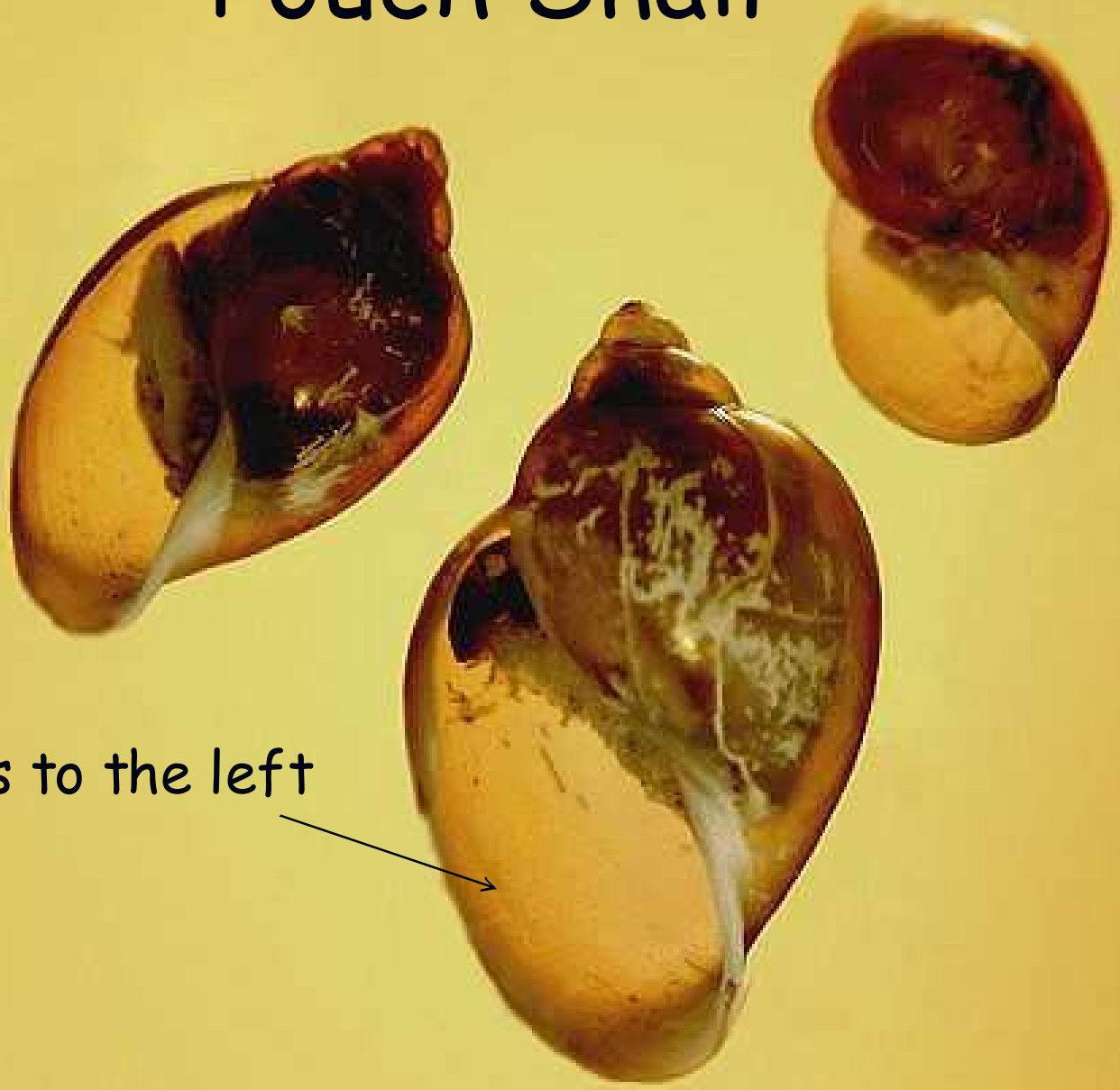


Black Fly Larvae

Photo courtesy of NABS

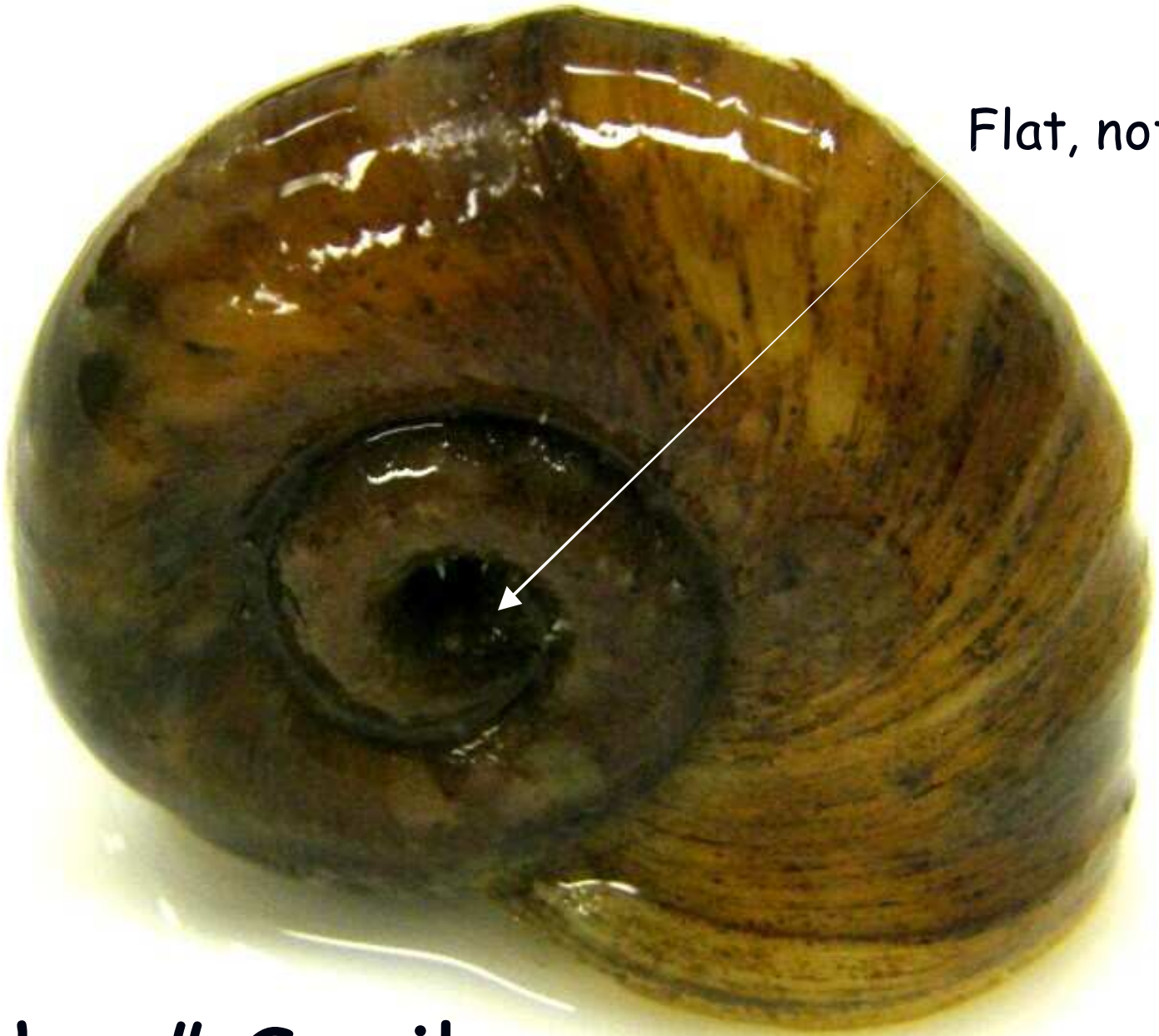

Leech
MDC photo

Pouch Snail



Shell opens to the left

MDC Photo

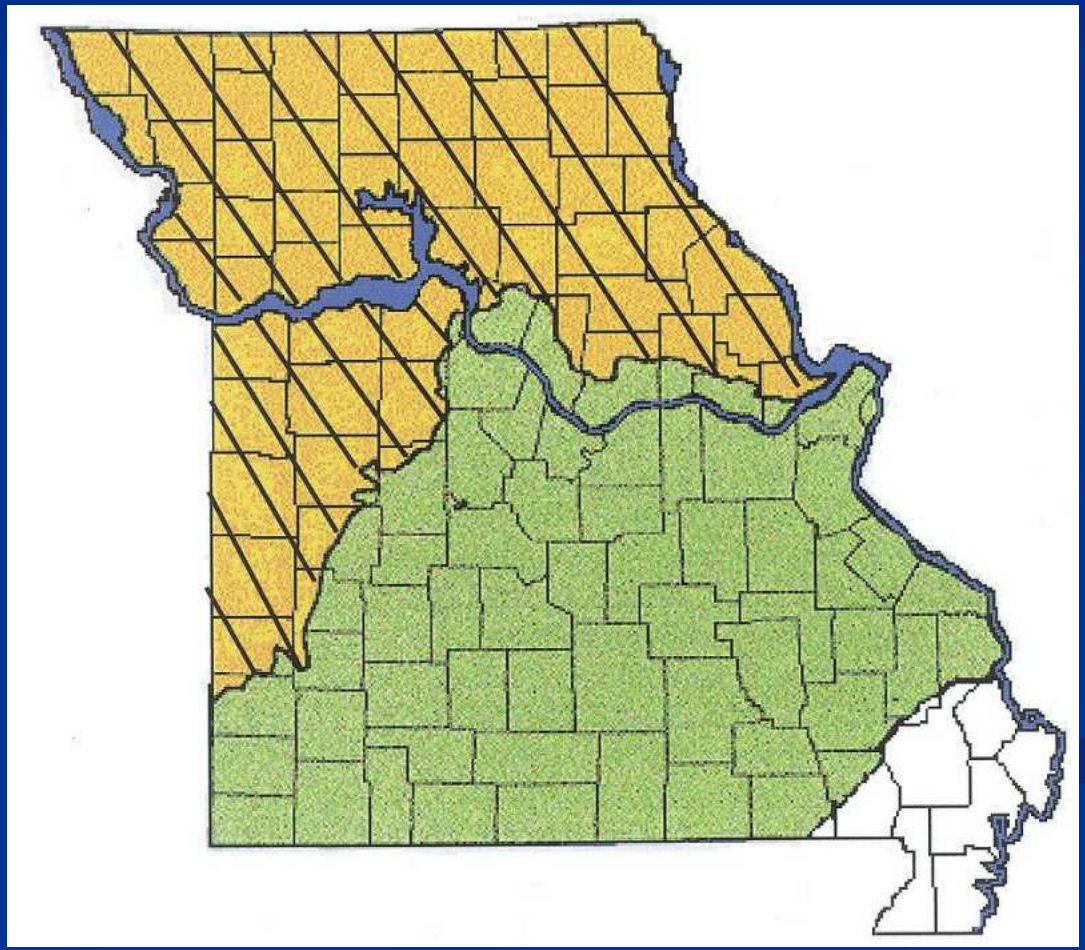


"Other" Snail

Sampling Methods

AQUATIC FAUNAL REGIONS

Big River Region
Lowland Region
Ozark Region
Prairie Region



Ozark Faunal Region

- Most streams in southern Missouri
- Steep gradient
  - Fast moving, lots of riffles
- Riffle-run-pool sequence
- Gravel and cobble substrate
  - Invertebrates adapted to interstitial spaces

Prairie Faunal Region
(Glaciated and Osage Prairie Regions)

- Most streams in north and west Missouri
- Low gradient
  - Slow moving, very few riffles
  - Naturally turbid → soil type
- Pool-run-pool sequence
- Sand, silt, shelf bedrock & shale bottom
  - Little interstitial spaces

Lowland Faunal Region

- Found in the Bootheel region of Missouri
- Wetlands drained by series of "ditches"
- Substrate
  - Faster moving water → sand or gravel
  - Slower moving water → silt-bottomed

EQUIPMENT

- 3'x3' net
- 3-pronged garden tool (optional)
- Sorting pan and/or white ice cube tray
- Forceps
- Squirt bottle
- Hand lens
- D-frame net (optional)

Replicate Sampling

SAMPLING STREAM HABITATS

- To determine water quality using invertebrates:
  - Three net sets
  - Three different microhabitats
- One or two net sets do not provide accurate representation of water quality.
- What are habitat types in Missouri streams?
- How do I find three habitats to sample?

STREAM HABITATS

Ozark Streams

Riffles

Root Mats

Prairie & Lowland Streams

Root Mats

Snags/Woody Debris

Non-Flow

STREAM HABITATS

Ozark Streams

Riffles

Root Mats

Prairie & Lowland Streams

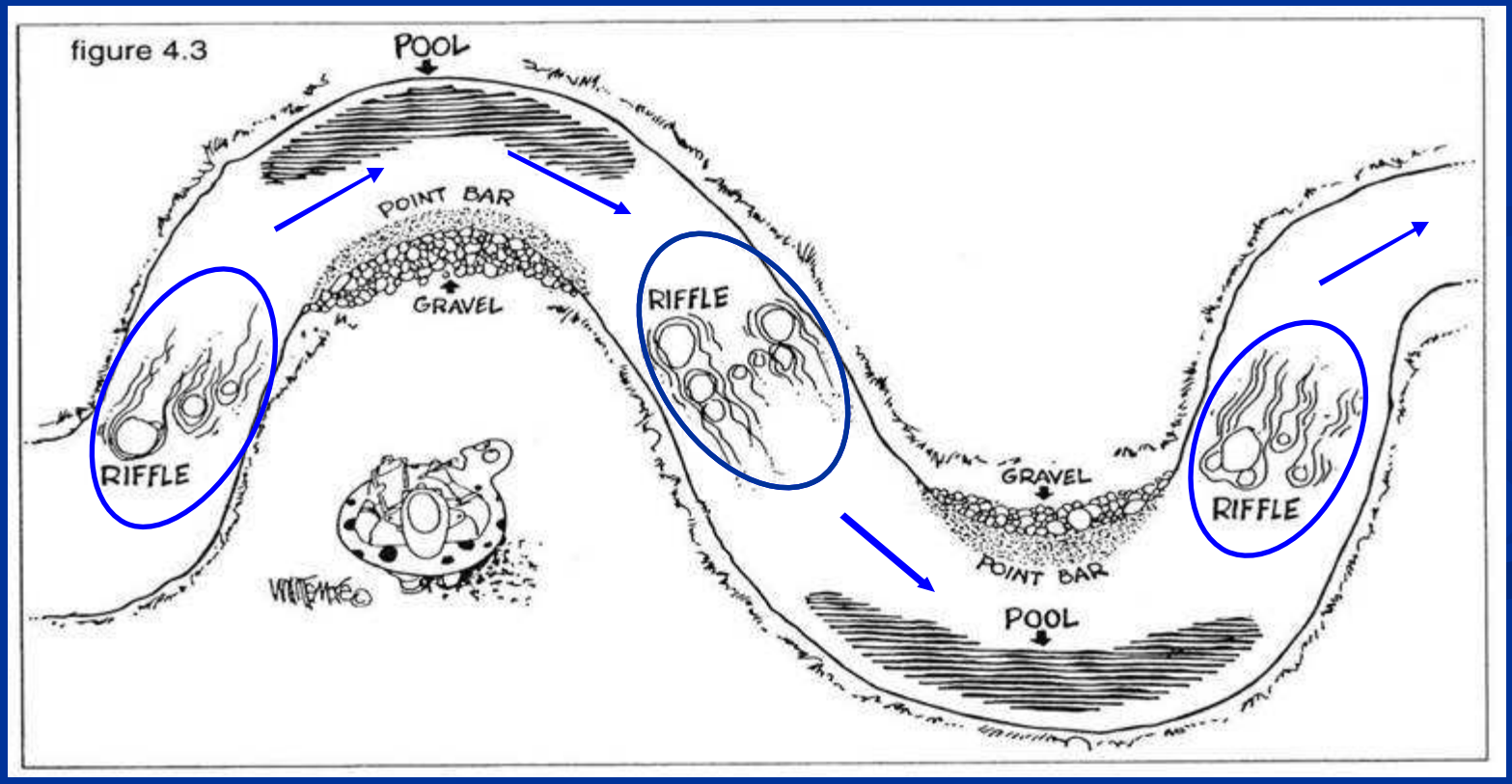
Root Mats

Snags/Woody Debris

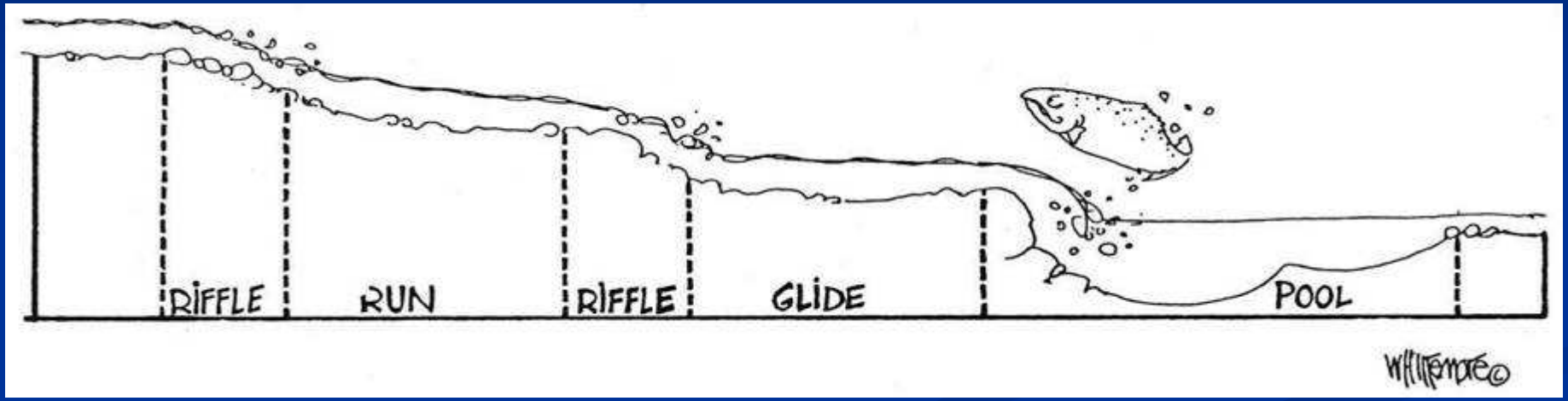
Non-Flow

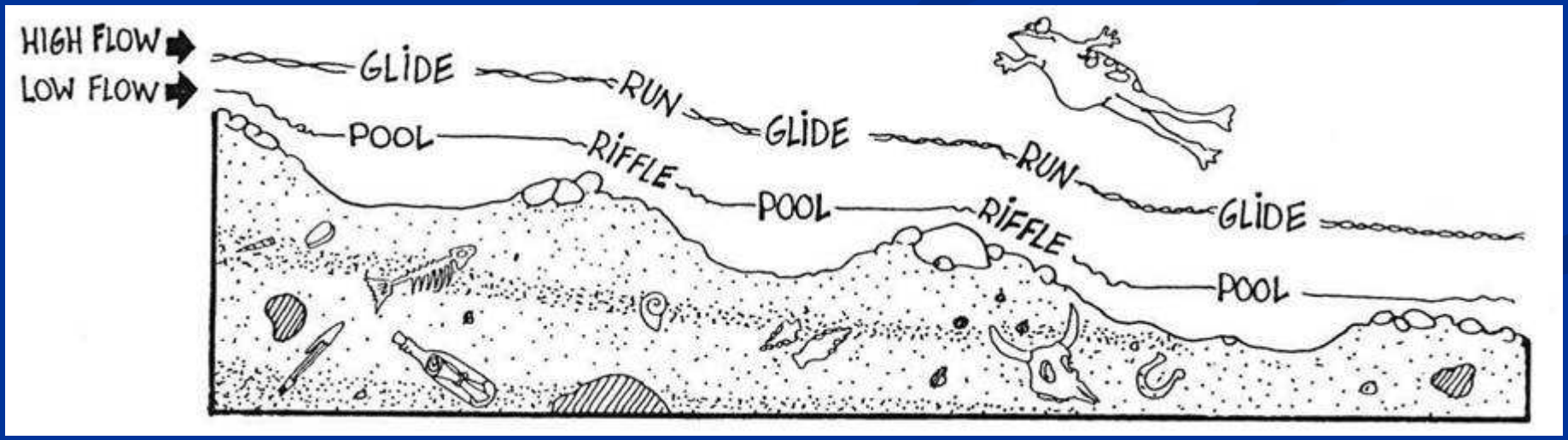
Riffle Definition

- **Riffle** - Area that is shallow and fast flowing due to a gradient drop.



Riffles


RIFFLE
RUN
RIFFLE
GLIDE
POOL


HIGH FLOW
LOW FLOW
GLIDE
RUN
GLIDE
POOL
RIFFLE
POOL
RUN
RIFFLE
GLIDE
POOL

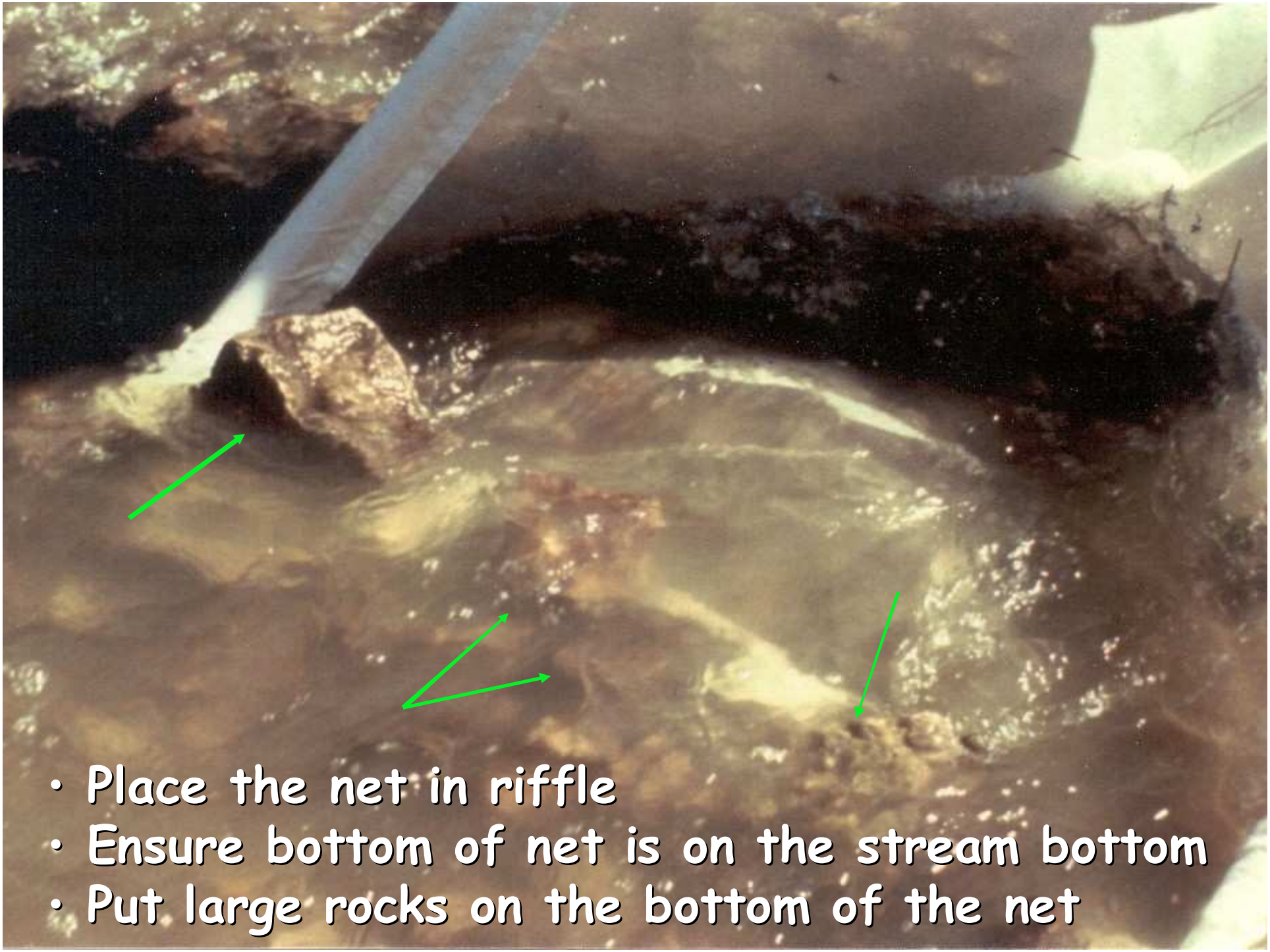

All within the same site!!

STABLE RIFFLE

- Provides a variety of habitats
- Aerates the water
- Brings food to many invertebrates

SAMPLE COLLECTION

- Place the net in riffle
- Ensure the bottom of net is on the stream bottom
- Rub all large stones (within the 3' x 3' area upstream of the net)
- Dance and kick (Be sure to disturb the substrate 3" to 6" deep)


• Place the net in riffle
• Ensure bottom of net is on the stream bottom
• Put large rocks on the bottom of the net


Rub all large stones


Do the 'Benthic Boogie'

Net Removal

STREAM HABITATS

Ozark Streams

Riffles

Root Mats

Prairie & Lowland Streams

Root Mats

Snags/Woody Debris

Non-Flow

SAMPLING NON-RIFFLE AREAS

- Root Mats -

Root Mat - Matted roots of vegetation hanging into the water or growing out of stream bank.


Root Mat

Root Hairs


Sample Collection

Net Removal

STREAM HABITATS

Ozark Streams

Riffles

Root Mats

Prairie & Lowland Streams

Root Mats

Snags/Woody Debris

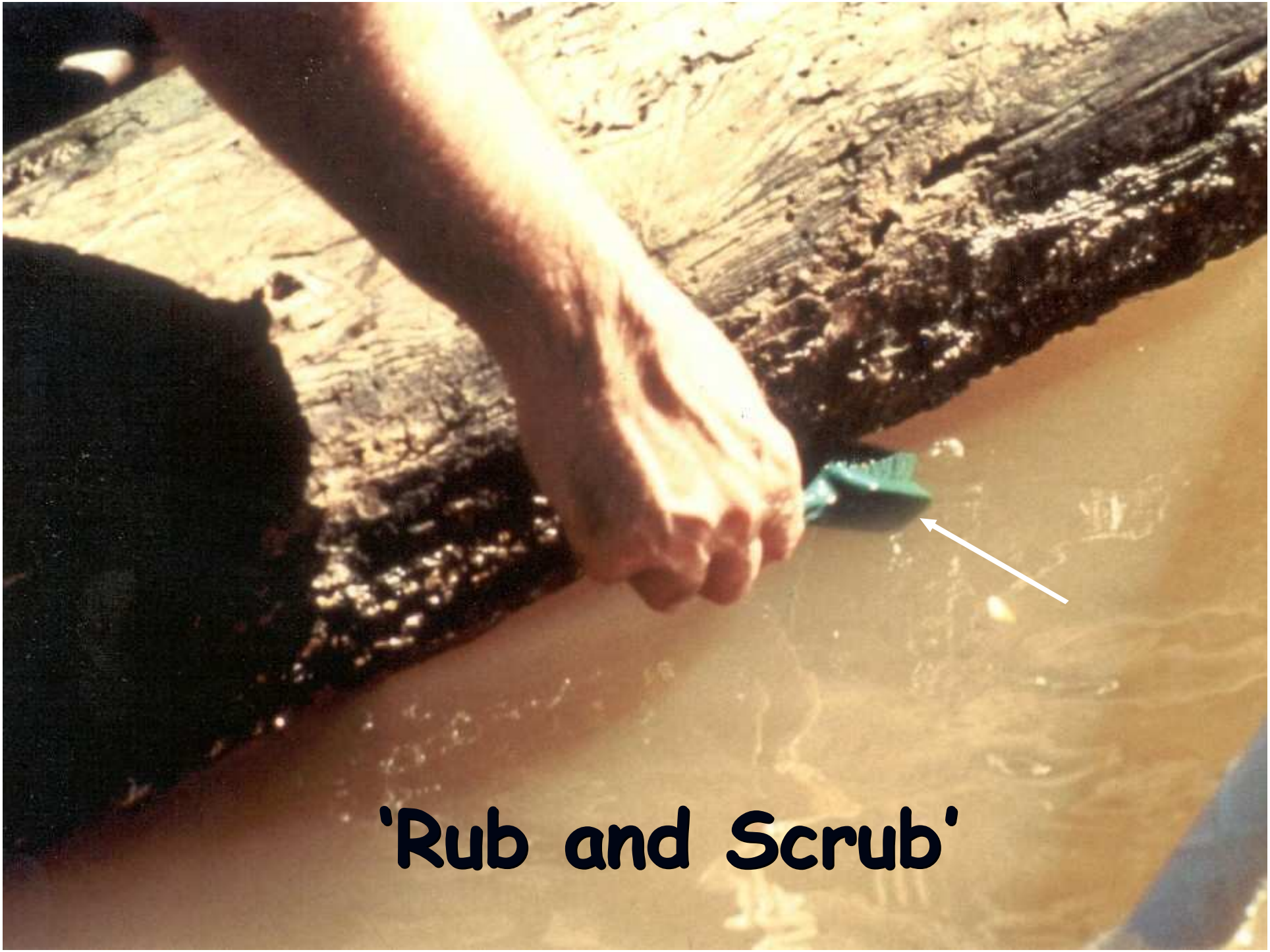
Non-Flow

SAMPLING NON-RIFFLE AREAS

- A SNAG -

Snag - Woody debris such as tree limbs, logs, and sticks that have fallen in water.


Snag


'Rub and Scrub'

STREAM HABITATS

Ozark Streams

Riffles

Root Mats

Prairie & Lowland Streams

Root Mats

Snags/Woody Debris

Non-Flow

SAMPLING NON-RIFFLE AREAS

- Non-Flow -

Non-Flow - Areas that are not in the main channel and do not have flow.

SAMPLE ANALYSIS

- Remove invertebrates from the net
- Record the time spent removing the invertebrates from the net
- Identify the invertebrates
- Count the invertebrates and record results

Front: Invert Data Sheet

MACROINVERTEBRATE DATA SHEET

Please check the box next to "Site #" *if this is a new site and please be sure to attach a map.*

☐ Site # _____ Stream _____ County _____

Site Description _____ Time _____

Date _____ Trained Data Submitter (person assuming responsibility for these data) _____

Trained Data Submitter's Stream Team Number _____ Rainfall (inches in last 7 days) _____

Trained Participants _____

Invertebrate Type	*Net Set #1*	*Net Set #2*	*Net Set #3*	*Score*
Habitat type →	→	→		*After entering the number (#) of organisms collected, circle the number below for every type of organism collected. Add the numbers circled and record the total as your Water Quality Rating.*
Time Spent Picking (Minutes picking x number of people picking)	min. picking ____ x # people ____ = total min. ____	min. picking ____ x # people ____ = total min. ____	min. picking ____ x # people ____ = total min. ____	
Sensitive	**# of Organisms**	**# of Organisms**	**# of Organisms**	**Circle Types Present**
Caddisfly Larvae				3
Hellgrammites				3
Mayfly Nymphs				3
Gilled Snails (right)				3
Riffle Beetles				3
Stonefly Nymphs				3
Water Penny Larvae				3
Somewhat Tolerant	**# of Organisms**	**# of Organisms**	**# of Organisms**	**Circle Types Present**
Other Beetle Larvae				2
Clams/Mussels				2
Crane Fly Larvae				2
Crayfish				2
Dragonfly Nymphs				2
Damselfly Nymphs				2
Scuds				2
Sowbugs				2
Fishfly Larvae				2
Alderfly Larvae				2
Watersnipe Fly				2
Tolerant	**# of Organisms**	**# of Organisms**	**# of Organisms**	**Circle Types Present**
Aquatic Worms				1
Black Fly Larvae				1
Leeches				1
Midge Larvae				1
Pouch Snails (left)				1
Other Snails (flat)				1
< 12 = Poor	12 – 17 = Fair	18 – 23 = Good	> 23 = Excellent	**Water Quality Rating** ____

Comments (mention any changes from your usual readings) _____

Fish Present (Please Mark) ☐ **Yes** or ☐ **No**

PLEASE KEEP A COPY AND SEND ORIGINAL DATA TO:

Priscilla Stotts/Water Protection Program
Department of Natural Resources
P.O. Box 176
Jefferson City, MO 65102-0176

Volunteer Monitoring - 1/07

Water Quality Volunteer

Back: Invert Data Sheet

Instructions for Biological Monitoring

- Collect three net sets of invertebrates from three different microhabitats. This ensures a more complete picture of what lives in your stream and more accurately reflects stream health. Adequate sampling can be achieved by one person with a D-frame net, but you may need two people if you use a kick net.
- If possible, take all three net sets from different areas within a stable riffle. Microhabitats to sample include differences in: rock size, flow, leaf packs and emergent vegetation.
- Always work in an upstream direction so that sampling activities do not disturb portions of the riffle to be sampled later.
- If, and only if, you do not have enough riffle habitat within your 300 ft. sampling site to collect three net sets, you may also want to sample alternative microhabitats.
    - Prioritize sampling of habitat types as follows:
        - Riffle
        - Root mat
        - Snags
        - Non-flow
    - Whatever you decide to sample at your site (e.g., two riffle net sets and one root mat), always sample those same three microhabitats at the site every time you sample there, and list the habitat type for each sample. This will ensure that the data you collect remains consistent over time.

Sampling Streams With Riffles

Sampling may require two people, one to hold the net and the other to dislodge invertebrates from the substrate.

1. **Place** the net in the riffle facing upstream, and tilt it enough to provide a "pocket."
2. **Ensure the bottom of the net** is on the stream bottom leaving no room between the net and substrate (prevents organisms from washing under the net).
3. **Rub all large stones** in the 3-foot by 3-foot (3' x 3') area immediately upstream of the net to dislodge invertebrates and wash them into the net.
4. **Dance** and **kick** with your feet in the 3' x 3' area until you have disturbed all of the substrate 3 inches to 6 inches deep to dislodge the invertebrates into the net.

Streams Without Riffles (or without riffles not large enough for 3 net sets)

Sample Collection from Root Mats – Adequate sampling requires two people.

1. Have one person place the side of the kick net against the bank on the downstream side of the root mat.
2. Make sure that the net is anchored to the stream bed.
3. The other person will then kick the root mat **in a swirling motion** with one foot to create a circular current in order to dislodge the invertebrates from the root mat. The circular motion of the sampler's foot will drive the invertebrates into the net, even if there is no current.

Sample Collection from Snags – Adequate sampling requires two people.

1. Have one person hold the net in a horizontal position about 6-12 inches under the water.
2. The 2nd volunteer will remove the snag from the water. When removing snags from the water, pull the snag out of the water quickly. If the snag is removed too slowly, the invertebrates may swim off.
3. Brush the snag down with a brush above the net to dislodge invertebrates.
4. Sample approximately 3 to 5 snags for one net set.

Sample non-flow areas in the same manner as a riffle, collecting three separate samples. However, the sampler will need to use a swirling motion with the foot to create a current to move debris into the net. Although this habitat can be sampled using a kick net, it is easier with a D-fame net.

Example 1: Invert Data Sheet

MACROINVERTEBRATE DATA SHEET

Please check the box next to "Site #" ***if this is a new site and please be sure to attach a map.***

☑ Site # 1 Stream Turkey Creek County Boone

Site Description 100 yds upstream from Hwy 163 Time 1300

Date 4/5/07 Trained Data Submitter (person assuming responsibility for these data) Shelley Banks

~~Trained Data~~ Submitter's Stream Team Number 1639 Rainfall (inches in last 7 days) 1.0

Trained Participants Chris Langdon, Tim Rielly

Invertebrate Type	*Net Set #1*	*Net Set #2*	*Net Set #3*	*Score*
Habitat type →	Riffle →	Riffle →	Riffle	*After entering the **number (#) of organisms collected**, circle the number below for every type of organism collected. Add the numbers circled and record the total as your Water Quality Rating.*
Time Spent Picking (Minutes picking x number of people picking)	min. picking 15 x # people 3 = total min. 45	min. picking 10 x # people 3 = total min. 30	min. picking 12 x # people 3 = total min. 36	
Sensitive	**# of Organisms**	**# of Organisms**	**# of Organisms**	**Circle Types Present**
Caddisfly Larvae				3
Hellgrammites	10	7	9	(3)
Mayfly Nymphs		45	30	(3)
Gilled Snails (right)				3
Riffle Beetles	20			(3)
Stonefly Nymphs				3
Water Penny Larvae	25	12	22	(3)
Somewhat Tolerant	**# of Organisms**	**# of Organisms**	**# of Organisms**	**Circle Types Present**
Other Beetle Larvae		2		(2)
Clams/Mussels				2
Crane Fly Larvae	1		2	(2)
Crayfish				2
Dragonfly Nymphs				2
Damselfly Nymphs				2
Scuds	1	10	3	(2)
Sowbugs				2
Fishfly Larvae	5			(2)
Alderfly Larvae				2
Watersnipe Fly				2
Tolerant	**# of Organisms**	**# of Organisms**	**# of Organisms**	**Circle Types Present**
Aquatic Worms	3	1	2	(1)
Black Fly Larvae	2	1	1	(1)
Leeches			3	(1)
Midge Larvae	4	4	1	(1)
Pouch Snails (left)	1			(1)
Other Snails (flat)				1
< 12 = Poor	12 – 17 = Fair	18 – 23 = Good	> 23 = Excellent	**Water Quality Rating 25**

Comments (mention any changes from your usual readings) _____

Fish Present (Please Mark) ☑ **Yes** or ☐ **No**

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Priscilla Stotts/Water Protection Program
Department of Natural Resources
P.O. Box 176
Jefferson City, MO 65102-0176

Volunteer Monitoring - 1/07

Water Quality Volunteer

Example 2: Invert Data Sheet

MACROINVERTEBRATE DATA SHEET

Please check the box next to "Site #" *If this is a new site* and please be sure to attach a map.

☐ Site # 1 Stream Turkey Creek County Boone
Site Description 100 yds upstream from Hwy 163 Time 1320
Date 9/30/08 Trained Data Submitter (person assuming responsibility for these data) Shelley Banks
Trained Data Submitter's Stream Team Number 1639 Rainfall (inches in last 7 days) 1.0
Trained Participants Chris Langdon, Tim Rielly

Invertebrate Type	*Net Set #1*	*Net Set #2*	*Net Set #3*	*Score*
Habitat type →	Riffle →	Riffle →	Riffle	*After entering the number (#) of organisms collected, circle the number below for every type of organism collected. Add the numbers circled and record the total as your Water Quality Rating*
Time Spent Picking (Minutes picking x number of people picking)	min. picking 15 x # people 3 = total min. 45	min. picking 10 x # people 3 = total min. 30	min. picking 12 x # people 3 = total min. 36	
Sensitive	**# of Organisms**	**# of Organisms**	**# of Organisms**	**Circle Types Present**
Caddisfly Larvae				3
Hellgrammites	3	1	1	(3)
Mayfly Nymphs		4	6	(3)
Gilled Snails (right)				3
Riffle Beetles	1			(3)
Stonefly Nymphs				3
Water Penny Larvae		5	1	(3)
Somewhat Tolerant	**# of Organisms**	**# of Organisms**	**# of Organisms**	**Circle Types Present**
Other Beetle Larvae		1		(2)
Clams/Mussels				2
Crane Fly Larvae	5		1	(2)
Crayfish				2
Dragonfly Nymphs				2
Damselfly Nymphs				2
Scuds				2
Sowbugs	4	4	10	(2)
Fishfly Larvae	5			(2)
Alderfly Larvae				2
Watersnipe Fly				2
Tolerant	**# of Organisms**	**# of Organisms**	**# of Organisms**	**Circle Types Present**
Aquatic Worms	25	15	22	(1)
Black Fly Larvae	100+	100+	15	(1)
Leeches			20	(1)
Midge Larvae	20	35	38	(1)
Mystery Snails (left)	42			(1)
Other Aquatic Worms				1
< 12 = Poor	12 – 17 = Fair	18 – 23 = Good	> 23 = Excellent	**Water Quality Rating** 25

Comments (mention any changes from your usual readings) The water quality rating hasn't changed, but there are so many more tolerant critters this year! This is a big change what does it mean?

Fish Present (Please Mark) ☑ Yes or ☐ No

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Volunteer Monitoring - 1/07

Water Quality Volunteer

FACTORS THAT AFFECT RATING

- Substrate
- Depth and Velocity
- Season
- Water Temp
- Flow
- Water Chemistry
- Physical Factors
- ID to Order

Count all invertebrates in all categories!

ANALYZING INVERTEBRATE DATA

Observation:

High density, high diversity, many sensitive species such as stoneflies, caddisflies, and mayflies.

Analysis:

No problem, good water quality.

ANALYZING INVERTEBRATE DATA

Observation:

High diversity, low density of species present.

Analysis:

Possibly due to poor habitat conditions.

ANALYZING INVERTEBRATE DATA

Observation:

Low diversity, high density of species present.

Analysis:

Organic pollution (nutrient enrichment) or sedimentation; excessive algal growth resulting from nutrient enrichment.

ANALYZING INVERTEBRATE DATA

Observation:

Low diversity, low density, or no bugs but the stream appears clean.

Analysis:

Toxic pollution (e.g., chlorine, acids, heavy metals, oil, herbicides, insecticides); unproductive.


OK! WHO HAS BEEN USING THE ICE TRAYS FOR BUG COLLECTING?
WHITTEMORE©


Sunset